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EARTHQUAKE HAZARDS REDUCTION ACT REAUTHORIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

NINETY-EIGHTH CONGRESS

FIRST SESSION

ON

REAUTHORIZATION OF THE EARTHQUAKE HAZARDS REDUCTION ACT

MARCH 3, 1983

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EARTHQUAKE HAZARDS REDUCTION ACT REAUTHORIZATION

THURSDAY, MARCH 3, 1983

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff member assigned to this hearing: Louis Blair, professional staff member; and Edward Smick, minority professional staff member.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. This is an authorization hearing pursuant to the National Earthquake Hazards Reduction Act.

I note before I give my opening statement that Mr. McLoughlin is already at the table. I think I will ask all four of the Federal agency witnesses to come up here at the same time. We will hear the statement of each of you and then ask questions of all of you. So if Dr. Peck, Dr. Sanderson, and Mr. Kammer will also come forward. When Mr. Kammer comes in, we will get him to join you.

Each year more than 1,000 earthquakes are detected in the United States. Although most are quite small and cause little or no damage, the potential exists for catastrophic effects.

According to estimates from the U.S. Geological Survey, a large earthquake in the Puget Sound area, for example, an area which has experienced several severe earthquakes in the past, could cause property damage of up to $200 million to $300 million, inflict as many as 10,000 casualties and leave 20,000 people homeless.

A severe earthquake in the Los Angeles area, on the other hand, could cause property losses of up to $50 billion and perhaps inflict 20,000 casualties.

In 1977, the Congress passed the Earthquake Hazards Reduction Act, developed largely by this committee, to establish a coordinated Federal program for research, prediction, mitigation efforts to minimize losses, and assistance to States and local governments for earthquake response planning activities.

In today's authorization hearing we will receive testimony from the four Federal agencies currently conducting work under the Earthquake Hazards Reduction Act. These agencies are: the Federal Emergency Management Agency [FEMA], which is the lead agency for planning and coordinating Federal earthquake mitigation efforts; the U.S. Geological Survey; the National Science Foundation; and the National Bureau of Standards.

In recent years the subcommittee has been concerned about the loose coordination of Federal efforts to meet all the requirements of the act, the degree of commitment of FEMA to the leadership role, and the absence of long-range program plans.

In 1980, Congress directed FEMA to submit by September 30, 1981 a 5-year plan for the earthquake program. We still have not received that plan. However, one of today's witnesses is chairman of an advisory body helping FEMA to prepare the plan. I hope that he and FEMA will speak on the progress in developing it.

In 1982, this subcommittee requested that the General Accounting Office assess the adequacy of the current organization of Federal earthquake activities, and especially the extent to which FEMA is carrying out its lead role. A representative of GAO will testify today as to that assessment.

I will place in the record an opening statement by Senator Hollings.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, during the 95th Congress I had a major role as Chairman of the Subcommittee on Oceans and Atmosphere in the enactment of Public Law 95-124, the Earthquake Hazards Reduction Act. My interest in and concern for public safety has not lessened. Indeed, the more the recently completed National Hazard Maps disclose the pervasiveness of the earthquake hazard throughout our nation, including my home state, the more important this program becomes.

While I do not want to pre-judge the thrust of the testimony we will hear today I do want to express concern over some elements of the program and express the hope that today's witnesses can alleviate that concern. One thing we can all agree on. No act of Congress will ever prevent an earthquake. But this Act can mitigate the human and economic consequences of earthquakes. It will do so if, and only if, its provisions and programs are carried out in a timely and competent manner. We must determine whether that is being done.

Is FEMA providing the management coordinaton necessary for effectiveness in a multi-agency program? Will the proposed termination of the National Bureau of Standards program in building research be offset by its reestablishment elsewhere, or has the Administration concluded that safety in and after an earthquake is unrelated to the integrity of stairs, ceilings, post-earthquake fire fighting capabilities, etc. which the NBS program seeks to integrate under earthquake engineering?

Mr. Chairman, It is my hope that Committee Members will look carefully into matters such as these during this hearing and reflect their findings in forthcoming authorizing legislation for the National Earthquake Hazards Reduction Act.

Senator GORTON. We will begin with a panel of four representatives of the Federal agencies conducting activities under the Earthquake Hazards Reduction Act. In order of presentation they are Mr. David McLoughlin, Deputy Associate Director for State and Local Programs and Support, Federal Emergency Management Agency; Dr. Dallas Peck, Director, U.S. Geological Survey; Dr. Jack Sanderson, Assistant Director for Engineering, National Science Foundation; and Mr. Raymond Kammer, Deputy Director, National Bureau of Standards, Department of Commerce.

Gentlemen, we welcome you to this hearing and look forward to your testimony, and we will start with you, Mr. McLoughlin.

STATEMENTS OF DAVID McLOUGHLIN, DEPUTY ASSOCIATE DIRECTOR FOR STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY; DALLAS PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY; JACK SANDERSON, ASSISTANT DIRECTOR FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION; AND RAYMOND KAMMER, DEPUTY DIRECTOR, NATIONAL BUREAU OF STANDARDS, DEPARTMENT OF COMMERCE

Mr. McLoughlin. Good morning, Mr. Chairman.

Senator Gorton. Please proceed. We have the written statements of each of you which will be included in the record in full. If you will summarize those statements in 5 or 6 minutes, we can go on to questions.

Mr. McLoughlin. It is a pleasure to appear before you, Mr. Chairman on behalf of Louis O. Giuffrida, the Director of the Federal Emergency Management Agency, to present FEMA's comments on the national earthquake hazard reduction program in connection with the reauthorization of the Earthquake Hazards Reduction Act of 1977.

I am presenting, as you have requested, only the highlights of my statement which has been made part of the record.

FEMA has assumed an active leadership role in the earthquake program. An earthquake policy group consisting of the senior officials charged with administering the respective agencies' earthquake programs has been formed to direct the overall activities of the Interagency Coordinating Committee.

The review of the 5-year program plan, responsibilities for developing the Federal response plan for a catastrophic earthquake and the activities of the Interagency Committee for Seismic Safety and Construction are now carried out under the Interagency Coordinating Committee.

FEMA has established an independent panel headed by Mr. Karl Steinbrugge to review the national earthquake hazard reduction program 5-year plan. Mr. Steinbrugge has formed a group of 25 experts representing all related disciplines to conduct these reviews and will be testifying here today on these activities.

As chair of the Subcommittee on Federal Earthquake Response Planning, FEMA has initiated an extensive planning effort involving at least 22 departments and agencies. The subcommittee has developed a planning guide that could be used as an interim operative plan for response and as the framework in developing a comprehensive national Federal plan. We expect that to be published in the Federal Register on March 4.

During the past year FEMA has continued to pursue a two-pronged activity to foster the development of improved seismic safety building provisions in both the private and public sectors. For the private sector, the Building Seismic Safety Council is conducting trial designs with tentative provisions developed by the Applied Technology Council.

This activity will result in the issuance of a source document for use by code organizations as well as State and local building officials. A program to encourage its adoption by the private sector is planned.

In a parallel effort, FEMA has continued to encourage Federal agencies to adopt similar and, if necessary, more stringent seismic provisions in their construction and grant leasing activities. The ICSSC has been restructured and given new policy level membership.

Under this new leadership, with increased high level management attention and greater resources, the ICSSC will show results during the next year.

It is essential that the program proceed in a cost-effective and organized manner. Therefore, I recommend that Public Law 95-124 be reauthorized for at least 3 years.

Thank you, Mr. Chairman. This concludes my testimony.

[The statement follows:]

STATEMENT OF DAVE McLOUGHLIN, DEPUTY ASSOCIATE DIRECTOR OF STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY

It is my pleasure to appear before this subcommittee on behalf of Louis O. Giuffrida, Director of the Federal Emergency Management Agency (FEMA), to present FEMA's comments on the National Earthquake Hazard Reduction Program (NEHRP) in connection with the reauthorization of the Earthquake Hazards Reduction Act of 1977.

FEMA assumed the leadership and coordination of the NEHRP when the program was transferred to FEMA with the establishment of the Agency in 1979 under the Presidential Reorganization Plan No. 3 of 1978. The United States Geological Survey (USGS), the National Science Foundation (NSF), and the National Bureau of Standards (NBS) are the other principal agencies involved in the NEHRP and represent the largest portion of the program activities and budget allocations. In addition, numerous other Federal agencies participate in various phases of the activities of the program.

The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124), as amended, identifies some of the objectives of the NEHRP as being:

1. Development of technologically and economically feasible design and construction methods and procedures to make new and existing structures, in the areas of seismic risk, earthquake resistant, giving priority to the development of such methods and procedures for nuclear power generating plants, dams, hospitals, schools, public utilities, public safety structures, high-occupancy buildings, and other structures which are especially needed in the time of disaster;

2. Implementation in all areas of high or moderate seismic risk of a system (including personnel, technology, and procedures) for predicting damaging earthquakes and for identifying, evaluating, and accurately characterizing seismic hazards;

3. Development, publication, and promotion, in conjunction with State and local officials and professional organizations, of model codes and other means to coordinate information about seismic risk with land-use policy decisions and building activity;

4. Development, in areas of seismic risk, of improved understanding of, and capability with respect to, earthquake-related issues, including methods of controlling the risks from earthquakes, planning to prevent such risks, disseminating warnings of earthquakes, organizing emergency services, and planning for reconstruction and redevelopment after an earthquake.

5. Education of the public, including State and local officials, as to earthquake phenomena, the identification of locations and structures which are especially susceptible to earthquake damage, ways to reduce the adverse consequences of an earthquake, and related matters;

6. Development of research on

(A) Ways to increase the use of existing scientific and engineering knowledge to mitigate earthquake hazards;

(B) The social, economic, legal, and political consequences of earthquake prediction;

(C) Ways to assure the availability of earthquake insurance or some functional substitute; and

7. Development of basic and applied research leading to a better understanding of the control or alteration of seismic phenomena.

These stated objectives can be grouped into four general categories of activities: basic research, mitigation, preparedness/response, and public education/information dissemination. All NEHRP activities fall into one of these categories in achieving the program objectives.

Last year, this Committee expressed concerns in its report on the hearing regarding FEMA's leadership role, NEHRP management and direction, and some specific program activities. Specifically:

The Committee wondered whether FEMA could effectively be the lead agency when other agencies have programs so much larger (budgets eight to ten times as large) and whether FEMA is devoting adequate resources and priority to meeting its responsibilities.

The Committee requested that the NEHRP or the Administration conduct an intensive review, preferably under independent leadership, to determine the best way to manage, structure, and staff the NEHRP to achieve the objectives stated in the Act and ensure adequate program management and direction.

The Committee requested the NEHRP to develop a detailed program plan—with increased cohesion among the four principal agencies, including conduct of joint projects and development of better-coordinated efforts and more-compatible budgets.

The Committee requested the NEHRP to increase the utilization and implementation of research-derived knowledge and FEMA to direct its attention to mitigation as well as post-earthquake response considerations.

The Committee expressed concern that the United States was still far from having an earthquake prediction capability comparable to ones that exist elsewhere in the world and international information exchange efforts should be increased.

In addressing these concerns, I would first like to assure the Committee that FEMA takes its responsibilities as the lead and coordinating agency for the NEHRP seriously and will devote whatever resources are required to ensure that the program receives the priority and attention needed to meet its objectives within FEMA and throughout the Federal Government. FEMA's activities in this regard will be discussed in addressing the specific management concerns expressed by the Committee.

The fact that FEMA has the smallest portion of the program activities is, we believe, an advantage rather than a disadvantage in providing the necessary leadership and management direction. FEMA has a broad perspective, a strong State and local interaction and interface network, and an integrated emergency management framework. This along with USGS's close working realationship with the various State geologists insures that all the objectives of the Act are met.

The response to the Committee's concerns regarding the direction of the direction of the whole program, the need for a five-year program plan, and FEMA's management and coordination roles, FEMA last spring selected Mr. Karl V. Steinbrugge, the internationally known expert, to conduct an independent review of the NEHRP. He was given a free hand to proceed in this task as he deemed best, and he in turn, selected a groupof 25 experts representing all relevant disciplines and State/local governments to aid him. FEMA has provided this Panel with a draft five-year plan, which represents a synthesis of materials provided by other Federal agencies conducting earthquake-related activities. The work of this review panel continues and Mr. Steinbrugge is testifying today on the status of his activities. Completion of the five-year plan will follow shortly after the review panel accomplishes its mission.

FEMA has assumed an active leadership role in the earthquake program. I would like to cite several examples of those leadership responsibilities. First, I have established an Earthquake Policy Group consisting of Drs. Jack Sanderson, Dallas Peck, John Lyons and me—the Administration officials charged with running our respective Agencies' earthquake programs. We have already met on several occasions to discuss substantive issues—the five-year earthquake plan and pending program hearings. This group directs the overall activities of the Interagency Coordinating Committee for the National Earthquake Hazards Reduction Program (ICC NEHRP) and charges them with specific tasks.

The ICC NEHRP has continued to meet and to discuss substantive issues. To ensure that there was only one coordinating committee, we have brought under the umbrella of the ICC NEHRP the responsibilities for developing the Federal response plan for the catastrophic earthquake as well as the activities of the Interagency Committee for Seismic Safety in Construction (ICSSC). Both activities are now carried out as subcommittees of the ICC NEHRP.

A third example is the development of the five-year plan, which I discussed previously. As a final example, FEMA and the USGS have executed a Memorandum of Understanding directed toward coordinating our joint efforts in specific earthquake-related areas. Already staff from our respective agencies have begun work in the following areas: operational response, prediction/warning, public information and education, and long-term mitigation. Attached to my testimony is a copy for the record.

NEHRP efforts to strengthen the mitigation, public information and education, and international exchange aspects of the program will be discussed by each agency in its program presentation.

During the past year, FEMA has continued to pursue a two-pronged activity to foster the development of improved seismic safety building provisions in both the private and public sectors.

For the private sector, FEMA funded an effort to be conducted by the Building Seismic Safety Council (BSSC). Representing all segments of the design and construction industry, the BSSC presently is conducting trial designs of the tentative provisions developed by the Applied Technology Council. For this effort, the BSSC is using the design of 27 buildings in four high- and moderate-risk areas (Los Angeles, Seattle, Memphis, and Phoenix). A second phase of this contract will include 20–25 more buildings in five to six additional cities (New York, Chicago, St. Louis, Fort Worth, Charleston, and possibly Boston). A concluding phase will evaluate the results of the trial designs, modify the provisions, as necessary, and derive regulatory and socioeconomic implications of the provisions. A source document for use of code organizations as well as State and local building officials will be issued and a long-range program of encouraging its adoption by the private sector will be started.

In a parallel effort, FEMA is pursuing a policy of encouraging Federal agencies to adopt similar and, if necessary, more-stringent seismic provisions in its construction and granting leasing activities. In this respect, it is essential that the Federal Government set a suitable example of earthquake mitigation by "getting its own house in order." The mechanism for action in the Federal sector is the Interagency Committee on Seismic Safety in Construction (ICSSC), in which 23 Federal Departments and Agencies participate. After developing and publishing a draft seismic standard for new Federal buildings in 1981, the work of the committee suffered from a somewhat lower level of attention and resources than would have been desirable. Consequently, Federal agencies have lagged behind in pursuing this area with vigor. During the past year, however, the ICSSC was assigned a new chairman, placed under the overall structure of the ICC NEHRP (as stated earlier), given new and policy-level membership, and restructured into a steering group and four subcommittees (instead of 10 subcommittees and a task group). Under this new leadership, increased high-level management attention, and greater resources, the ICSSC will show results during the next year.

FEMA's projects within the overall NEHRP consist primarily of assisting State and local governments in carrying out their responsibilities for public safety and welfare, ensuring that the States and local communities have the information and tools needed to develop their programs and educate the public, and develop a Federal response plan and ensure earthquake hazard mitigation within Federal programs.

During fiscal year 1982, FEMA's work with the States and local communities in site-specific high and moderate seismic risk areas to develop preparedness and mitigation programs has continued to develop and expand in scope. As vulnerability analyses conclude, preparedness plans are developed. These critical plans for saving lives when the event occurs are essential. Following the response planning effort, the focus shifts toward mitigation efforts and increased public awareness and education is support of those activities.

The Southern California Earthquake Preparedness Project (SCEPP) is now beginning to shift from the initial response planning to the longer-term mitigation and education activities. The processes developed under SCEPP soon will be transferred to other high and moderate siesmic risk areas that are in the early phases of program development—vulnerability assessment and preparedness planning. In a manner similar to actual response and recovery operations, vulnerability assessment and preparedness planning lead to the awareness needed to initiate an effective mitigation effort for future events. By developing a mitigation program after the preparedness process is well underway, the communities' awareness of hazards, community responsibilities, and needs has been heightened.

In previous testimony, I have discussed the comprehensive, multihazard approach FEMA has initiated in its realignment. A good example of FEMA's comprehensive approach and how it can benefit all natural hazard reduction efforts including earthquakes is a pilot project that we are exploring with the State of Utah and other Federal agencies under our dam safety program. The cities of Salt Lake, Provo, and Ogden are situated along the Watasch Fault. About 85 percent of the State's population lives in this area beside the mountain slopes and along the valleys. Also in this area of high seismic risk are numerous dams that could fail as a result of a severe earthquake. As preparation for an earthquake, a hospital emergency room facility with emergency generators has been established by Utah's emergency services department. However, if dams were to fail as a result of an earthquake or in the course of a flood event, the stored water would rush down the canyons and the low-level emergency facility could be flooded. Thus, a real need exists for a multihazard approach to the State's emergency services, leading to our exploration with the State of a pilot project on multihazard monitoring and a real-time warning system.

Each preparedness and mitigation project area is unique. Study areas may include a major city, such as Boston; encompass several cities and counties, such as the San Francisco Bay and Puget Sound areas; involve more than one State, such as the Central U.S. and Charleston, S.C., study areas; and possibly require a cooperative planning partnership with another country, such as Upper New York State with Canada, San Diego with Mexico, and Puerto Rico with adjacent Caribbean governments. Because of the unique characteristics of these earthquake study areas, it is not practical to assume that identical coalitions can be formed in each area. It is, however, possible to replicate the basic support concept and process.

Because some at-risk areas of the country are not as familiar with earthquake processes and hazards as California, FEMA has initiated a hazard awareness and education program for these areas. We will be field testing these products in the central and southeastern United States through a prototype community outreach project. This project will establish earthquake education centers (EEC) in existing institutions in these areas. The EECs will recruit and train a cadre of volunteers to extend the EEC community outreach capability. These EECs will be models for additional centers scheduled for funding in other areas in late fiscal year 1984 and beyond. Both the USGS and NSF have agreed to participate in this prototype effort by supplying the EECs with materials and assisting in developing tracking mechanisms for continuous project evaluation.

To ensure that the Federal Government is prepared to respond to a catastrophic earthquake (in California and any high-risk, high-population area of the country), FEMA initiated an extensive planning effort that will involve at least 22 Federal Departments and Agencies. At this time, the focus of planning is on Federal augumentation of State and local government response capability with the support necessary to save and protect lives and meet basic human needs.

To coordinate this planning effort, FEMA established and chairs a Subcommittee on Federal Earthquake Response Planning under the auspices of the ICC NEHRP. During the past six months the subcommittee developed a planning guide that establishes a framework for development of a comprehensive National Federal Plan. The guide could serve also as an interim operation plan for response.

Within the next few days, a notice will be published in the Federal Register to officially initiate the planning effort and to involve the Departments and Agencies not included on the subcommittee. The notice includes a schedule for plan development and exercises, with a full exercise in April 1985 to test the ability of the Federal Government to respond to a catastrophic earthquake in California. This plan and exercise program schedule satisfies the timeframes established by the Emergency Mobilization Preparedness Board (EMPB) and the earthquake response implementation measures assigned to FEMA in the EMPB's National Plan of Action for Emergency Mobilization.

In the meantime, Regional Federal planning continues under the leadership of FEMA Region IX in California. A final plan is almost completed and ready for submission to the National level for review. Numerous other Federal agencies have been involved in this effort and previous response efforts in Salt Lake City and Puget Sound. The experience of these Regional efforts will be used as the basis for the National planning effort. An important objective of the National plan development is to establish the policies and procedures that should be applied throughout the Federal establishment while at the same time allowing flexibility to recognize constraints and opportunities that are unique to response in a particular geographic risk area.

It is essential that the program proceed in a cost-effective and organized manner. Therefore, I recommend that Public Law 95-124 be reauthorized for at least 3 years, as proposed by Interior in its draft legislative proposal.

Thank you, Mister Chairman, that concludes my testimony. I would be glad to answer any questions.

Senator GORTON. Thank you, Mr. McLoughlin. You summarized that testimony very well, and well under par for the time.

Dr. Peck.

Dr. PECK. Thank you. It is a pleasure to be here today.

Today marks the 104th anniversary of the Geological Survey. It was founded March 3, 1879, and has served the Nation since as the Nation's geologist involved in topographic and geological mapping, monitoring and providing information on water resources, and assessing geologic resources and hazards.

Our work in geologic hazards involves research, monitoring, hazard assessment and warnings of volcanic eruptions, earthquakes and landslides or other ground failure. The work is not purely academic. I have a responsibility as Director to issue warnings, when possible, of geological catastrophes.

The geologic hazard we address today concerns earthquakes. When earthquakes are mentioned in the context of the United States, we usually think of California. Earthquake risks, although concentrated in that State, are nationwide. Boston, St. Louis, and Charleston regions have all experienced strong and damaging earthquakes in the past.

In 1949 and 1965, the Seattle, Wash., region was shaken by significant earthquakes that killed several people and did tens of millions of dollars of damage.

Our written statement addresses four issues over which the committee has in the past expressed concern: Funding for earthquake work, status of earthquake prediction, leadership in the national program, and utilization of research. In addition, I might comment that the Secretary of the Interior has requested that the authorization bill be amended so that it is extended to last for 3 years.

As far as the budget is concerned, the appropriated funding over the past 6 years has remained fairly constant, at about $30 million. Increased appropriations in fiscal year 1983 are due in part to a transfer of $1.2 million from the National Science Foundation for work previously done on a reimbursable basis.

Fiscal year 1984 requested funding of $29.5 million reflects the administration's policy to hold discretionary Federal spending in check and the requirements of other programs under the Geological Survey. With the funds available, we shall keep essential monitoring and data service activities intact.

Most of the reductions will be concentrated in theoretical and laboratory studies, although some monitoring in areas of lower risk may be reduced.

In the area of earthquake prediction, earthquake prediction remains a challenging problem that we have yet to solve. However devastating, major earthquakes are fairly rare. Thus, the opportunity to gain experience in predicting them does not happen often.

We have dense geochemical and geophysical monitoring networks in California and elsewhere that are being used to study the problem and have been the basis for advisories issued by the Geological Survey.

Despite our continued research and our initial efforts at earthquake warning, we do not issue earthquake predictions and advisories on a routine basis. To do so would require a significant increase in our scientific understanding of earthquake processes, and in addition a major investment in equipment, data transmission lines and computers.

We cannot recommend a major investment in an operational earthquake prediction system at this time given the current state of our knowledge. We shall, however, continue to work to improve our scientific understanding and our monitoring capability.

In the area of program leadership, during the past year we have worked with FEMA to improve the direction and coordination of the National Earthquake Hazard Reduction Program. We have executed a memorandum of understanding between our agencies. We have met on the earthquake program with Lee Thomas, who up until a few days ago was Associate Director of FEMA and had participated in the development of a 5-year plan.

We are confident that these steps and the sense of cooperation that has developed between our agencies will allow FEMA to increase the effectiveness of its leadership role in the national program.

In the area of utilization of research, we have worked very hard to see that the results of our research are placed in the hands of the potential users. Every year we conduct two to four workshops. We bring scientists and the users together so that the scientist can explain his or her results to the users.

As an example of this approach, I have two reports here. One is a collection of scientific papers on the investigations of the New Madrid, Mo., earthquake region.

The second is a report of a workshop on continuing actions to reduce losses from earthquakes in the Mississippi Valley area. During the workshop, plans for implementing earthquake hazard reduction procedures were developed, and these plans are contained in this report.

This ends my oral statement. We look forward to continued participation in the program.

[The statement follows:]

STATEMENT OF DR. DALLAS L. PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

INTRODUCTION

This statement is submitted in response to the invitation of February 9, 1983, from the Honorable Slade Gorton to the Director of the U.S. Geological Survey (USGS) to participate in a hearing on the reauthorization of the Earthquake Hazards Reduction Act of 1977. We request that this statement be included in the record of the hearing.

PURPOSE AND SCOPE

The purpose and scope of this testimony, the fourth on this subject we have submitted to this Committee, are somewhat different than those of our earlier statements. In previous statement we have set down in some detail the activities of the USGS under the National Earthquake Hazards Reduction Program (NEHRP). We shall not repeat the detailed information provided previously on the nature of our efforts but rather, after a brief review of the background of earthquake work in the USGS, focus our discussion on the issues raised in Senator Gorton's kind invitation—budget considerations and earthquake prediction—and on other issues regarding the overall Federal program and research utilization.

BACKGROUND

Most of the earthquake related work within the Geological Survey falls under Objective (2) of the Earthquake Hazards Reduction Act, that is:

"the implementation in all areas of high or moderate seismic risk, or a system (including personnel, technology, and procedures) for predicting damaging earthquakes and for identifying, evaluating, and accurately characterizing seismic hazards.".

To make clear the responsibility of the Geological Survey with respect to earthquake prediction, the 1980 amendments to the Earthquake Hazards Reduction Act gave the Director of the USGS authority to issue an earthquake prediction or other earthquake advisory as he deems necessary. This reinforced the authority given to the Director of the USGS under the Disaster Relief Act of 1974 to issue warnings for an earthquake volcanic eruption, landslide, or other geologic catastrophe. Since 1978 seven earthquake advisories have been issued by the Director of the USGS regarding four separate regions of the United States. We have reviewed these points to emphasize that the USGS has major responsibilities relative to the issuance of earthquake warnings and, in fact, warnings of all geologic hazards, and that we are actively responding to these responsibilities. Although the USGS is often considered as an organization engaged chiefly in research, we have given and shall continue to give the application of our research to more accurate and more useful warnings and assessments of all geologic hazards high priority and importance within our organization.

BUDGET

Since the passage of the original legislation in 1977, the funding for the earthquake program has remained fairly constant. Table 1 (below) shows the funds (in millions of dollars) authorized and appropriated for earthquake hazards reduction work within the USGS for the past 6 years.

TABLE 1

[In millions of dollars]

	Fiscal year						
	1978	1979	1980	1981	1982	1983	1984
Authorization	27.5	35.0	40.0	32.5	34.4	31.8	....
Appropriation	30.2	28.0	31.6	32.3	32.7	[1] [2] 34.5	[2] 29.5

[1] Includes $1.2M transferred from the National Science Foundation to the USGS to support work previously done on a reimbursable basis.

[2] Fiscal year 1984 funding is the President's proposed budget.

The earthquake program budget reduction proposed for fiscal year 1984 reflects the Administration policy to hold Federal discretionary spending in check and the requirements of programs with equal or higher priority within the Geological Survey. Such programs are those involving mineral or land assessment surveys; however, even some of these programs are planned for reduction in fiscal year 1984.

In planning for a reduction in support for the earthquake program, consideration has been given to keeping a core team of scientific personnel intact, maintaining the continuity and integrity of basic data sources, and continuing to provide information, assessments, and warnings to the public on earthquake occurrences and hazards. Given these choices our strategy is to allow the cadre of scientists working in the areas of earthquake prediction and earthquake potential estimation to decrease by attrition, to reduce theoretical and laboratory studies in those areas, to reduce the density and areal extent of geophysical monitoring networks in areas considered to be at lower risk, and to maintain the earthquake hazard assessment and public information and warning activities at a constant level.

Within our fiscal year 1984 budget we shall continue support of the National Earthquake Information Service and the worldwide and nationwide data collection, analysis, and dissemination activities associated with that center. We shall continue to operate networks of instruments designed to record only strong ground shaking from large earthquakes. This data is extremely valuable to engineers and architects involved in seismic-resistant design. A program of regional earthquake hazards assessments, important to the mitigation of hazards in the long term, will continue. These studies are straightforward, relative to earthquake prediction research, and do not involve high operating expenses.

In the area of earthquake prediction research, reductions will be taken in the support of theoretical and laboratory research and to some degree in data collection in those regions thought to be at lower risk. We shall, to the extent possible, maintain our geophysical and geochemical monitoring efforts along and near the San Andreas fault in central and southern California. Based on quantitative assessments of earthquake potential, these areas of the United States are most likely to give rise to damaging earthquakes within the next few decades. Nevertheless, in order to continue high priority studies in areas of moderate seismicity such as the Salt Lake City, Puget Sound, and the St. Louis-Memphis regions, some adjustment in monitoring of less seismically active areas in California may be necessary.

EARTHQUAKE PREDICTION

Review

The goal of earthquake prediction is to give a warning of large, damaging earthquakes at a time interval long enough to allow appropriate actions by the public and private sectors. On the other hand, the time and location associated with the prediction must be given with enough precision to avoid sustained disruptive effects that the prediction response may have on society.

Ideally, we would like to predict, with high confidence, damaging earthquakes at specific locations and times 10 years before the event. With our current understanding, earthquake prediction is likely to resemble the forecasts of many phenomena; the precision of the forecast in time and space increases as the time interval between the present and the anticipated event decreases.

The average interval between major earthquakes on the southern San Andreas fault near Los Angeles, California, is estimated to be about 140 years with a 30-year uncertainty in this average. The ability to make such estimates is one of the major advances of the earthquake program during the past 5 years. The concept of the seismic cycle has developed in which strain is continuously stored near the boundaries of slowly moving sections or plates of the Earth's crust. The strain is released suddenly by slippage along faults at interplate boundaries giving rise to earthquakes. The interplate boundaries have been shown to have characteristics that vary with location. Some regions are characterized by long intervals between large earthquakes, others by more frequent and less severe earthquakes, the net energy release remaining the same in both cases.

If the length of the seismic cycle (or interval between large earthquakes) in southern California is 140 years on average, and a useful prediction must be accurate to within say 7 days, we must estimate the ending of the seismic cycle with an accuracy of about 0.99 percent. The fact that the length of the average time between large earthquakes can be estimated to only within 30 years, or 20 percent, makes the prognosis for precise, long-term earthquake predictions, made years in advance of the actual event, rather discouraging. Nevertheless, regional earthquake potential assessments based on average recurrence rates can be very useful in assigning priorities for general earthquake hazard mitigation activities.

If earthquakes are considered to be the failure of a mechanical system (the Earth's crust) under strain, then there is cause for hope that reliable and useful short-term earthquake predictions can be made. The argument is that when mechanical systems fail they often give some precursory physical sign that failure is imminent. A stick that is being bent will pop and crack just before it breaks. Materials that are being stressed at a constant rate in the laboratory will deform at a different rate just before failure. The strategy for successful earthquake prediction must be based on observing and understanding those phenomena that occur in the Earth's crust just before the catastrophic failure of the crust in a large earthquake.

To complicate the problem, the physical processes that culminate in an earthquake take place at depths of up to 30 miles in the crust and are hidden from direct view. Scientists involved in forecasting the weather can make direct observations in three-dimensions of the atmospheric conditions. In earthquake prediction we measure only the surficial effects of phenomena that take place within the crust with little hope of ever observing these processes directly. The fact that we measure effects of effects (or second-order phenomena) makes the problem more difficult to solve.

As pointed out above, large destructive earthquakes are relatively infrequent phenomena. Large earthquakes near dense networks of geophysical instrumentation are rare. Where hurricane forecasters may get a few opportunities each year to check and refine their theories, the opportunities to test prediction theories for large earthquakes are a few a century and the data base upon which to base a prediction is short and sparse.

To summarize, earthquake prediction is not a fully developed subject that can be implemented by simply employing existing scientific knowledge, technical skill, and engineering principles. The physical processes that culminate in an earthquake are generally hidden from view but are likely to be similar to those processes found in the failure of strained mechanical systems. However, the specific physical laws governing earthquake occurrence are not as well understood as, say those governing the weather. Compared to weather forecasting, there are relatively few opportunities to obtain data with which to test and develop theories for earthquake prediction.

Earthquake prediction systems

Because of the likelihood of a major earthquake in California and because of the size of the population at risk there, we have concentrated the phenomenological study of earthquake prediction in that State. Over 60 percent of earthquake prediction program funds are used to support monitoring efforts in California. These efforts include:

The operation of over 500 seismograph stations (figure 1).

Twenty-five geodetic strain monitoring networks containing several hundred survey lines (figure 2).

Crustal deformation and fault offset monitoring at over 200 sites (figure 3).

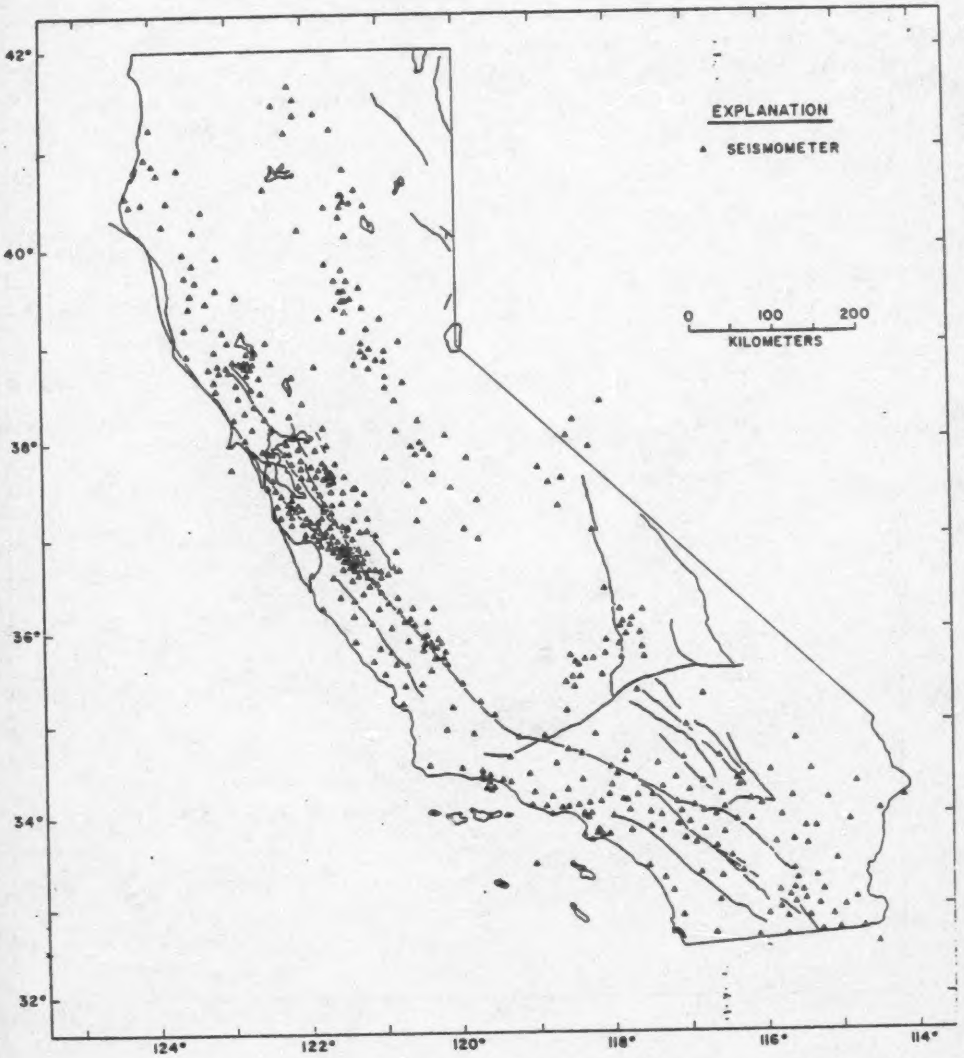
Various other geochemical and geophysical observations at approximtely 150 additional sites (figure 4).

Although these instruments are maintained by competent personnel and the data interpreted by dedicated scientists, these efforts cannot be looked upon as an operational earthquake prediction network for the following reasons:

The most crucial element of an operational or prototype earthquake prediction system is the science itself. There does not exist today a simple equation for issuing an earthquake prediction. Earthquake advisories have been issued in the past, and will continue to be issued, based on our best judgment at the time, but we do not yet have the experience or knowledge that will allow systemizing earthquake predictions. Because such knowledge and experience are based on scientific advances and the occurrence of earthquakes themselves, it is difficult to estimate when such a systemization of earthquake prediction will be possible.

In some cases the data are not continuously recorded or transmitted to a central data center, although this deficiency is being corrected.

FIGURE 1


42°
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EXPLANATION
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FIGURE 2

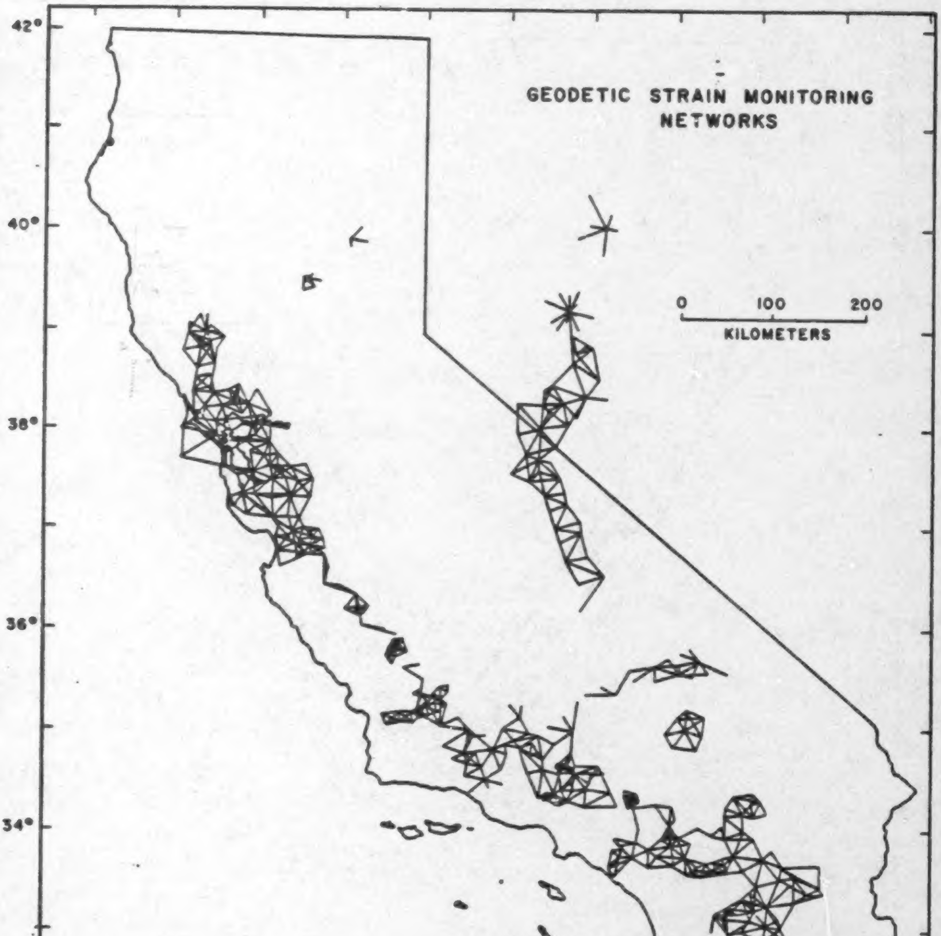
GEODETIC STRAIN MONITORING NETWORKS
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FIGURE 3

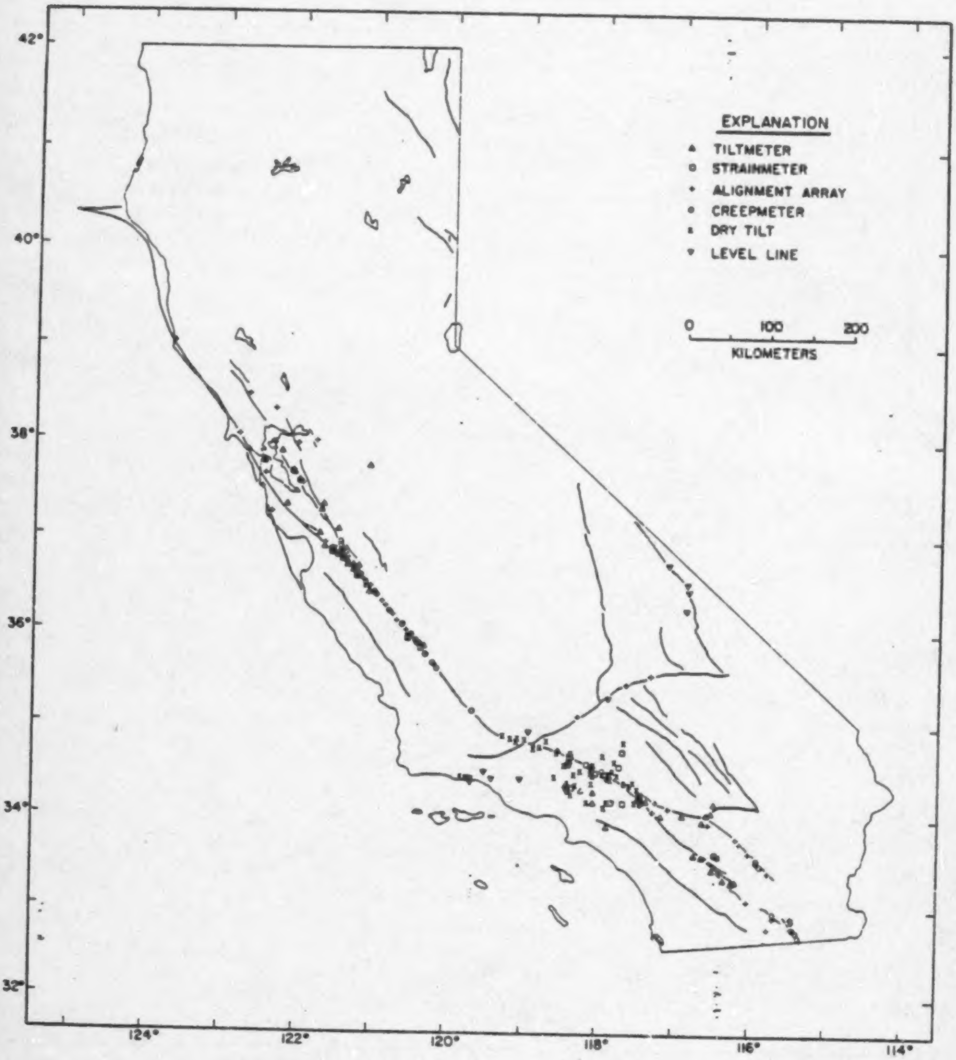
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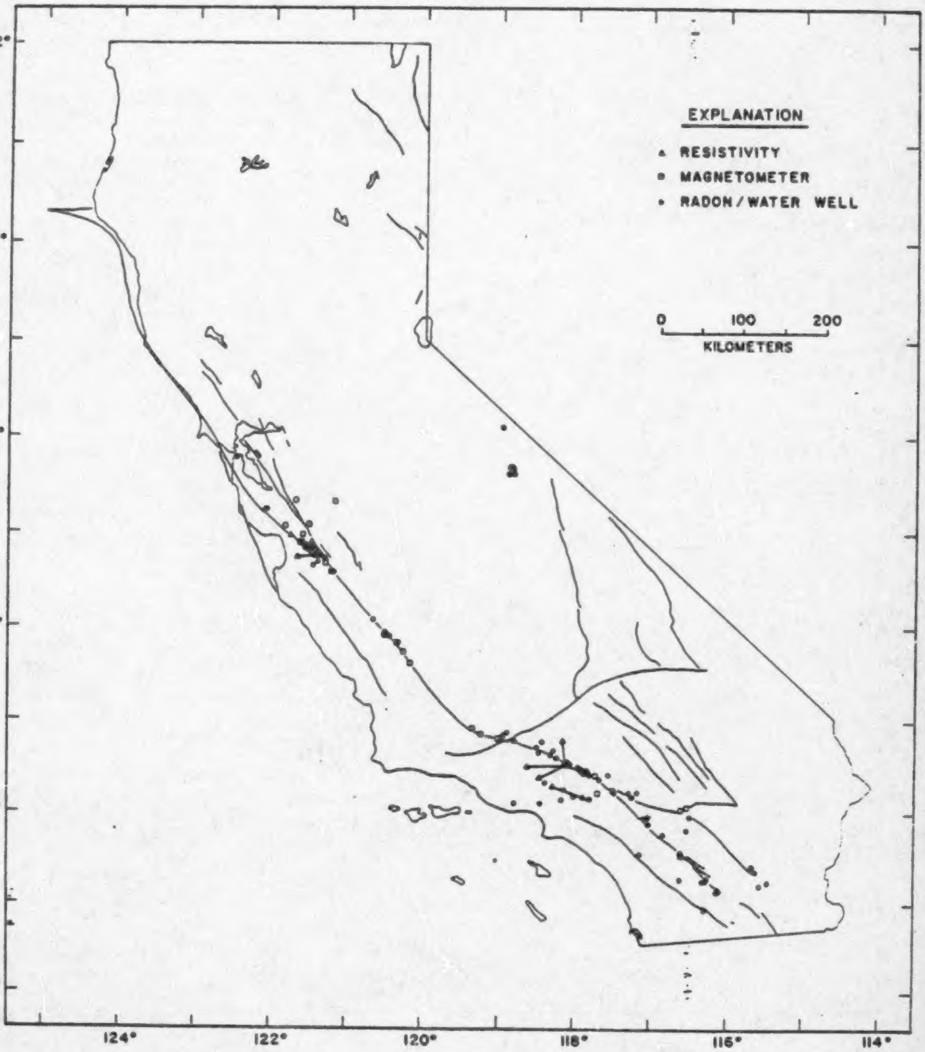
FIGURE 4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In the cases where the data are continuously transmitted to a data center, they are transmitted over commercial telephone circuits of variable reliability.

At most of the sites the instruments are placed on or near the surface of the Earth, as opposed to being placed in deep (1 km) boreholes to avoid the effects of the annual and daily cycles of weather and temperature.

On the other hand, the data processing activities associated with some of the earthquake prediction data are fairly sophisticated. Although not all of the data gathered from the field are transmitted to a data center, the data that are transmitted to data centers are automatically digitized and entered into computers for further analysis. Data centers are maintained at Pasadena (for southern California data) and Menlo Park (for central California data) where transmitted data are kept in computer files and displays summarizing all data maintained. Data that are not transmitted electrically to a data center must be physically collected from the field, and may be up to 2 months old before they are incorporated into the data displays. Data review meetings are held periodically, and on an ad hoc basis if necessary, to assess the situation, to deploy additional instrumentation or to perform special analysis if deemed necessary.

There are two approaches that can be taken to an "operational" prototype earthquake prediction system for southern California.

The first approach is the one we are embarked on now where instruments deployed for research purposes and analytical techniques developed in that research are incorporated into routine analysis and warning procedures. Those instruments and techniques that are proven unreliable or irrelevant to earthquake prediction are dropped in favor of more useful activities. We believe this course will provide the data that will be most useful in predicting the next major earthquake in southern California and at the same time provide for the research that will allow for interpretation of the data to be made with accuracy and understanding.

A less evolutionary approach, one that has been adopted in Japan, is to immediately deploy dense arrays of geophysical instrumentation in deep holes isolated from surface effects. Data from these instruments would be transmitted to data centers over dedicated, robust communication links. The data centers would be manned 24 hours a day and sophisticated data storage, display, and analysis facilities would be available. We are developing a conceptual design for a system of this type and plan to support further engineering studies of such a system this year. We believe it is prudent to have these design studies available in case of major scientific advances that would greatly increase our confidence in the effectiveness of such a system. However, given the apparent high cost of such a system and our lack of a more complete understanding of the physical process that occur immediately before large earthquakes, we do not recommend that this approach be carried further than the design phase at this time.

Thus the question of when will an earthquake prediction system for southern California be "operational" cannot be given a simple answer. It depends on the rate at which we gain experience with understanding the physics of earthquake occurance. The national effort to put a man on the Moon was the application of high and sophisticated technology to a set of fairly well-known physical laws. In earthquake prediction we are still trying to develop a clearer understanding of the latter, and we believe it is premature to advise a massive application of the former.

ORGANIZATION OF THE FEDERAL PROGRAM

In 1981 the Federal Emergency Management Agency (FEMA) was assigned the role as lead agency to "plan and coordinate" the NEHRP. During the last year we feel that major strides forward have been made in working more closely with FEMA and the execution of a coordinated program. Examples of this increased degree of dialogue and coordination are:

(1) During the past year the Director of the USGS has met on four occasions with Lee Thomas, Associate Director of FEMA for State and Local Programs, to discuss problems facing the NEHRP. Each of these meetings has proven extremely valuable in the coordination and the direction of the program. In fact, they have proven so valuable that we have tentatively agreed to meet on a regular quarterly basis with key representatives from the National Science Foundation and the National Bureau of Standards to continue to increase the discussion and coordination of the NEHRP at a high level in our respective agencies.

(2) A Memorandum of Understanding (MOU) has been signed between the USGS and FEMA outlining areas of responsibilities and future cooperation between the two agencies. This MOU was the result of a 2-day meeting in Reston during October 1982, in which discussions between our staffs were comprehensive and candid. These

discussions identified four specific areas that deserve particular attention and for which annexes to the MOU are being developed. These areas are: Effective, coordinated response by FEMA and the USGS to a potential or existing geologic or hydrologic hazard; dissemination of information on predictions or advisors of geologic or hydrologic hazards; public preparation, education, and response to hazard information and predictions; and implementation of long-term hazard mitigation practices.

(3) After informal discussions between our staffs, we have recently received a request from FEMA that a USGS seismologist be detailed to FEMA to assist both our agencies in the coordination and execution of the NEHRP. We are proceeding to identify candidates for this position and hope to have one of our scientists in place at FEMA within the next few months.

Given these examples, we believe it may be asserted that the USGS and FEMA are taking a series of positive actions toward closer coordination of their efforts and the definition of FEMA's leadership role within the NEHRP.

At present, budget preparation and the appropriation of funds are done independently in each of the agencies participating in the NEHRP. We cannot speak for the other agencies involved but our view is that this arrangement should be maintained while drawing on the close communication ties that have been established and are described above. As indicated earlier in this statement, the USGS conducted earthquake prediction and hazard reduction studies before the passage of the 1977 legislation and the Director of the USGS had responsibilities and authorities involving warnings of geologic hazards independent of the Earthquake Hazards Reduction Act.

In summary on this issue, we feel that substantive progress has been made in our degree of cooperation and planning with FEMA and that the results of this progress should be allowed to work within the existing budgetary and funding authorities of the individual agencies participating in the NEHRP.

MITIGATING THE EFFECTS OF EARTHQUAKES

In the Committee hearings last year concern was expressed that the research programs in NSF and in USGS have developed considerably more technical and scientific knowledge than is being utilized. We share the Committee's concern in this area and have concluded that the production of research results and their publication in reports and journals does not ensure their application. We have further concluded that mailing a report on earthquake hazards to State or local officials is not enough. Our present approach is to bring the scientists, the producers of the information, the State and local officials, and the users of the information, together in a series of workshops so that the nature of the information and its applicability can be explained in face-to-face sessions.

Actions we have taken to increase the utilization of our research include:

(1) A position of Deputy Chief for Research Application has been created within the Office of Earthquakes, Volcanoes, and Engineering to facilitate and focus the responsibility for research utilization.

(2) The USGS conducted a workshop in Knoxville, Tennessee, in September 1981 on, "Preparing for and Responding to a Damaging Earthquake in the Eastern United States." This workshop brought together, for the first time, 70 individuals representing local, State, and Federal government, business and industry, and the research community.

(3) As a follow-up to the Knoxville effort, a workshop was held in St. Louis in May 1982 on "Continuing Actions to Reduce Losses from Earthquakes in the Mississippi Valley Area." A report of this workshop has been prepared (USGS Open-File Report 83-157) to set down the results of the meeting. A companion report on the seismicity of the New Madrid, Missouri, seismic region has been published (USGS Professional Paper 1236) that summarizes the results of our scientific studies in the area. These two reports document two complementary actions required for the mitigation of earthquake hazards. The scientific studies and the planning at State and local levels are required to use the results of the scientific work.

(4) Three additional workshops are planned in 1983 to continue to foster earthquake hazard mitigation in the Eastern United States. These will be held in Charleston, South Carolina; Boston, Massachusetts; and Little Rock, Arkansas.

We are fortunate that support for these workshops is shared between the USGS and other agencies such as FEMA, NSF, and the Nuclear Regulatory Commission. Nevertheless, the USGS, plans, conducts, and reports the results of these workshops, and thus we take considerable pride in this strong initative in research utilization.

This concludes our statement on the issues facing the Geological Survey in the execution of its responsibilities under the National Earthquake Hazards Reduction

Program. Although significant scientific problems remain, considerable progress has been made in the past 6 years. Problems of managing a complex program, research utilization and warning and prediction systems have been identified and are being addressed in a forthright manner.

As these issues are joined, we look forward to further progress in earthquake hazards reduction.

Senator GORTON. Thank you, Dr. Peck.

Dr. Sanderson, we will hear from you now.

Dr. SANDERSON. Thank you, Senator Gorton.

I am pleased to be able to report to you today on the progress that has been made in the earthquake hazard research activities at the National Science Foundation. Since the passage of in 1977, the original Hazards Reduction Act, we have obligated about $135 million for research in this area. In the Directorate for Atmospheric, Astronomical, Earth, and Ocean Sciences, the Foundation has supported fundamental studies on the properties of seismic phenomena; and in the Engineering Directorate program it has supported research on topics in earthquake engineering and related fields.

In response to your questions, first we are very concerned about enhancing the utilization of research findings coming out of both of these directorates and have been using a variety of mechanisms to achieve this utilization. We are also continually striving to improve the procedures already developed and to identify new procedures. Second, the National Bureau of Standards phasedown of earthquake-related activities will have some potential impact on the liaison between the National Science Foundation and the user community, and it has led to the Foundation taking actions to further strengthen the ties which we already have to the private sector groups that will be involved.

Within the Foundation, basic Earth sciences research has followed the guidelines set by the 1976 Newmark-Stever report. In fiscal year 1983 we are funding the program at $7.5 million and are requesting a 10.6-percent increase in fiscal year 1984. Seismology and other earthquake-related topics have constituted the bulk of research in this area.

The earthquake hazard mitigation program, which is now in the Directorate for Engineering, has remained an identified and focused program within the Foundation since the early 1970's. For the past 2 years it has been in my directorate. Funding for the program grew from $9.3 million in fiscal year 1977 to $17.7 million in fiscal year 1978 following passage of the original act. It has remained essentially constant since then; however, we are proposing a 9.8 percent increase for that program in fiscal year 1984.

The earthquake hazard mitigation program is divided into three general areas. The siting research area deals with understanding strong ground motions at specific locations and the behavior of the soils. The other two areas are design research and research into societal response mechanisms.

Coordination with other agencies is accomplished both on a formal and informal basis. We have worked very well with FEMA as the lead agency and find it is an effective mechanism. In addition, we have direct participation in a significant number of other organizations and committees which are listed in my written testimony. More important, perhaps, are the activities of our grantees, who are very strong participants and leaders in seismic research throughout the country. Incidentally, Mr. Chairman, there are a number of researchers from institutions within your own State, including Dr. Neil Hawkins, chairman of civil engineering at the University of Washington, who is a member of our advisory commmittee for this area.

In 1969 a National Academy of Sciences committee chaired by Dr. George Housner of the California Institute of Technology conducted a study of earthquake engineering research. We recently recommissioned the Academy of Sciences to conduct a followup study, and Dr. Housner again chaired the new committee for this study. The report from that study has just become available. It documents the technological and societal advances that have been made since 1969 and also identifies the areas of needed future research. This will be one of the many important documents that go into our planning activities.

Pressures to constrain the budget in recent years have made more important two approaches that we have been using to document and to develop our research activities. The first is a very strong component of international cooperation using facilities and joint research efforts with a number of other nations. The second is a very active program of acquiring earthquake data from throughout the world, since many areas of the world are much more seismically active than the United States.

We are presently in the second phase of a very productive, cooperative project with the Japanese which includes testing of full-scale reinforced concrete and steel structures in a unique facility that Japan has built at Tsukuba, their science city.

In the research program within the Engineering Directorate, future activities will emphasize the response of materials to dynamic forces, more large and full-scale testing to verify and develop new concepts for structural design, inelastic behavior of structures subjected to seismic loads, special instrument arrays in highly seismic areas of the world, increased emphasis on low-rise structures, the type that are constructed throughout most suburban areas, and also such issues as lifeline facilities—the highways, gas, utilities, and services which are vital to a community and which, if damaged in an earthquake, have potential for causing serious harm.

We will also be continuing our study of the impact of earthquakes on community social and economic systems and trying to develop procedures that can minimize the harm that earthquakes cause.

Thank you, Mr. Chairman. The rest of my statement will be in the record.

[The statement follows:]

STATEMENT OF DR. JACK T. SANDERSON, ASSISTANT DIRECTOR, ENGINEERING, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and members of the subcommittee, I am pleased to report to you today on the status of earthquake research at NSF. Since the passage of the Earthquake Hazards Reduction Act in 1977, NSF has obligated about $135 million on seismic research in the directorates for engineering (ENG) and for astronomical, atmospheric, earth, and ocean sciences (AAEO). Approximately 80 percent of the funds have been obligated by the engineering directorate and 20 percent in AAEO. These programs at NSF have proved to be an effective expenditure of public funds.

I would first like to address the questions that were submitted to Dr. Knapp by letter of February 9, 1983. (1) We are very concerned about enhancing the utilization of research findings to the public and private sector. A variety of mechanisms are presently being utilized for this purpose and will be discussed in more detail later in my testimony. We are continually striving to improve these procedures. (2) The administration has reviewed the National Bureau of Standards earthquake-related activities and determined that these activities should be done by the private sector and State and local government, hence no specific plan has been prepared by NSE to directly offset this reduction. We are taking actions to establish strong ties to the private sector groups that will be involved.

The existing allocation of responsibilities among the various agencies involved in the National Earthquake Hazards Reduction Program is well established. We also find appropriate the organizational structure consisting of FEMA as the lead agency with the other participating agencies, each having its own budget within the agency appropriation.

The earthquake problem is truly national in scope because most States have some degree of seismic risk. Further, studies by the U.S. Geological Survey (USGS) indicate that the probability of a large earthquake in California is increasing each year.

Although the greatest seismic hazard is presently believed to be on the West Coast, recent concern has been expressed about possible earthquakes in the eastern United States, similar to the 1811-12 New Madrid, Miss. and the 1886 Charleston, S.C. earthquakes. Should earthquakes occur in a major metropolitan area, extensive property damage and loss of life could result, particularly when man-made facilities are not seismically resistant.

I will discuss the research activities with the Division of Earth Sciences (AAEO) and the problem-focused earthquake hazard mitigation program (EHM) resides in the Division of Civil and Environmental Engineering (ENG).

Funding for the program in the AAEO directorate followed option B of the guidelines set by the 1976 Newmark-Stever Report throughout the duration of those guidelines. In fiscal year 1983 we are funding that program at $7.5M. The funding requested for fiscal year 1984 is $8.3M, an increase of 10.6 percent.

In the AAEO directorate, the fundamental earthquake studies element is supported primarily through the seismology and deep earth structure program of the Division of Earth Sciences. Seismology is the primary method of studying the structure and physical properties of the Earth's interior and of defining the plates making up the Earth's lithosphere. As such, seismology and other earthquake related topics have constituted an important part of the division's program for some 20 years. This research consists of detailed studies and measurements directed at understanding the natural phenomena involved in an earthquake. The major goal is to provide the basis scientific framework on which more empirical programs of earthquake prediction can be based.

This program of fundamental seismological studies at NSF can be defined in terms of two broad categories: Plate tectonics and the earthquake process. The concept of plate tectonics states a small number of rigid plates form the Earth's outer surface and the movement of these plates relative to one another is responsible for earthquakes, volcanic eruptions, and many other phenomena. When we know much more about why and how the plates move, we will have the basis of a much better understanding of many processes in the earth, which should lead to the prediction of earthquakes.

The earthquake process itself is less well understood and is the subject of much attention. We do not yet know what physical parameters are the most critical or the details of rock properties that cause an earthquake. The failure criteria of crustal rocks and the role of pre-earthquake deformations must be understood in order to calculate the re-initiation of motion on the fault and to determine the total seismic energy that is released. In addition, the material properties and the nature of the geology affect the amount of energy released and the characteristics of the generated motion.

The EHM program, which is in the directorate for engineering, has remained intact since the early 1970's. As reorganizations within NSF have occurred over the years, the EHM program has functioned with continuous support within the directorate of research applications (RA), the directorate for applied science and research applications (ASRA), and the directorate for engineering and applied science (EAS). For the past 2 years it has resided in the directorate for engineering (ENG). Funding for this program was increased from $9.3 million in fiscal year 1977 to $17.7 million in fiscal year 1978 following passage of the original act. It has remained essentially constant through fiscal year 1983. The importance and urgency of the earthquake problem in society causes us to request an increase of 9.8 percent for fiscal year 1984.

The general objective of the EHM program is to conduct research which will lead to minimum property damage and loss of life from potentially damaging earthquakes. To accomplish this objective requires broad participation in the research program by architects, urban planners, Earth scientists, geotechnical engineers, structural engineers, and social scientists. For budget purposes, the EHM program is divided into the three general research areas of siting, design and societal response whose specific objectives are:

Siting research, which seeks to determine from instrumentation and geotechnical data the nature of strong ground shaking during earthquakes, to develop analytical procedures to predict the spatial and temporal distribution of strong ground motion at different sites, to understand the dynamic behavior of soil and rock subject to strong shaking, and to understand the behavior of the ocean, particularly its margins, due to underwater earthquakes producing damaging tsunamis.

Design research, which aims to develop procedures for performing dynamic analyses of proposed or existing structures under earthquake loadings, to develop an understanding of material, components, and structural systems subjected to damaging dynamic loads, and to develop procedures for the analysis and design of nonstructural and architectural systems subjected to earthquake loadings.

Societal response research, which studies and evaluates measures that can be used to mitigate society's losses due to earthquakes, including emergency preparedness, land use planning, building codes, insurance, and information and education, as well as other actions communities can take to withstand earthquakes and other disasters with minimal impact on both life and property.

Because of the urgency in making preparations for a major earthquake, we have not been content with only reporting research results in technical journals, but have attempted to accelerate the utilization of findings. This has required extensive interaction with other Federal agencies, and when appropriate, with State and local officials. For example, NSF co-sponsored the International Earthquake Conference that was held at the University of Southern California on February 7-11, 1983. Support for the Conference was also provided by the Agency for International Development (AID), the U.S. Geological Survey (USGS), and the Federal Emergency Management Agency (FEMA). The Conference was designed for policy makers and administrators in local governments facing earthquake risks. Over 200 representatives from several seismic-threatened countries, including the Philippines, Italy, Japan, Mexico, and Peru attended the Conference and shared their experience in attempting to understand, mitigate, and prepare for destructive earthquakes. The multi-national presentations at the Conference will result in the publication of recommendations for reducing earthquake hazards in vulnerable urban areas throughout the world.

The researchers participating in the EHM program have the added responsibility to interact with the ultimate users of the research. This has been effective because the EHM program has attracted many of the most productive and respected researchers and engineers in both the universities and the private sector, many being members of the National Academies of Science and Engineering. The stature and wide-ranging involvement of such individuals as consultants to other government agencies and private sector firms have provided a direct mechanism for introducing research results into practice.

In a more traditional mode, the EHM program has established and maintained the National Information Service for Earthquake Engineering (NISEE) at the University of California, Berkeley and at the California Institute of Technology. These facilities attempt to retain all pertinent information on earthquake engineering (including documents from foreign countries) in the form of technical publications, computer codes, and journal abstracts. Similar cataloging of pertinent information on the social science aspects is maintained in the National Hazards Research and Application Information Center at the University of Colorado. We also have supported numerous seminars, workshops and conferences to introduce the users to the latest advancements in technology.

Coordination with other agencies is accomplished both on a formal and informal basis. Direct participation in the following organizations has provided NSF effective mechanisms for coordination: Interagency Coordination Committee on National Earthquake Hazard Reduction Program (ICC/NEHRP); Universities Council on Earthquake Engineering Research (UCEER); Earthquake Engineering Research Institute (EERI); United States-Japan Committee on Natural Resources (UJNR)—panel on wind and seismic effects; Committee on Seismology (NAS-NAE-NRC); Committee on Natural Disasters (NAS-NAE-NRC); International Tunneling Association (ITA); California Seismic Safety Commission; Interagency Discussion Group on Disaster Mitigation (IDGDM): Interagency Committee on Seismic Safety in Construction (ICSSC); Building Seismic Safety Council (BSSC); Emergency Mobilization Preparedness Board—Working Group on Earthquakes (OSTP); and NSF and USGS advisory committees.

To facilitate an unbiased evaluation of the earthquake engineering research needs, a committee is being formulated under the auspices of the National Research Council. In addition, a review group, consisting of policy-level administrators from NSF, U.S. Geological Survey, Federal Emergency Management Agency and National Bureau of Standards, was recently established for the national earthquake hazards reduction program, which will provide formal coordination among the involved agencies on a periodic basis. NSF also works closely with the lead agency (FEMA) in preparing an annual report to Congress and the 5-year plan for the national earthquake hazards reduction program.

Extensive interaction and joint research projects with the USGS, FEMA, NBS, and numerous other agencies are also an integral part of our program. An important activity in past years has been the funding by NSF of the national strong motion instrumentation program, which is conducted by the USGS. To effect better coordination, the funding for this activity ($1.2 million) was transferred to the USGS in fiscal year 1983, and hence is not included in the budget proposed for fiscal year 1984.

While each research project is making a contribution to our understanding and mitigation of earthquakes effects, I would like to highlight a few of the more significant recent achievements to give you an idea of the wide range of activities in which we are engaged.

First, substantial advances have been made in recent years in plate tectonics and the earthquake process. The following is a brief summary of some of these advancements in each of the two broad categories of fundamental seismological studies at NSF:

PLATE TECTONICS

Delineation of "seismic gaps" and a map of seismic potential for the simple major plate boundaries of the world.

Increased knowledge of the nature of subduction zone earthquakes and the physical processes by which they are generated.

The association of the location of particular intraplate earthquakes with faults and other tectonic features.

THE EARTHQUAKE PROCESS

The introduction of a new, more quantitative measure of the "size" of an earthquake, the moment.

A better understanding of the dynamic processes of faulting—how a fault rupture nucleates, spreads, and finally stops, and the effects seen in seismograms from each of these three stages in the faulting process.

The discovery that a number of major earthquakes have been preceded by a premonitory clustering of small earthquake events in their epicentral regions.

Secondly, with respect to earthquake engineering:

Theoretical advancements and computer technology have resulted in models capable of reproducing the strong-motion seismograms recorded for past earthquakes. When the input parameters for a specific site have been determined, these ground motion models will be capable of predicting the damaging ground motions for a future earthquake. This procedure was considerably enhanced when MIT researchers were able to measure in the field, for the first time, the earthquake response of sediment filled valleys. The measurements were made through a unique set of instrument data from a cooperative research project in the Garm District of the Republic of Rakjikistan of the U.S.S.R.

To verify experimentally new concepts and develop an understanding of materials and structural behavior under seismic loading conditions, it is necessary to simulate actual earthquake ground motions. This has been accomplished in the laboratory by the development of one- and two-dimensional "shake tables". And cyclic test equipment. A technique of controlled detonation of explosives also has been developed (SRI) to simulate the earthquake ground motions under field conditions, and during the past year, has been improved to simulate strong earthquake ground motions of up to 15 seconds duration.

Unreinforced masonry buildings present the greatest vulnerability to seismic damage of any of our existing stock of buildings. Research investigations into the dynamic response of unreinforced masonry walls has produced the necessary data to enable the city of Los Angeles to enact an ordinance requiring owners to upgrade their unreinforced masonry buildings to be seismically resistant. Owners of the more than 9,000 unreinforced masonry buildings are complying with the ordinance.

Of extreme importance following an earthquake is the satisfactory performance of lifelines, i.e., gas, water, sewer, communications, transmission lines, highways, etc. research is being directed at the total lifeline problem for a metropolitan area as well as for specific areas.

NSF is also participating in a project that involves the introduction to this country of the new method of making a structure seismically resistant, namely base isolation. This procedure was studied in earlier research projects. It is proposed that it be used in a new public building in San Bernadino, Calif.

Both policy makers and operating units from a range of organizations have benefited from the useful research on the social and economic aspects of hazard reduction strategies. The results from this research have been used by local, State, and national organizations to improve mitigation and preparedness efforts and to develop disaster warning and post-disaster recovery measures. This societal response element of the EHM program focuses on the socioeconomic aspects of pre-disaster activity, such as hazard reduction, as well as such post-disaster activity as recovery. In the past year, NSF-sponsored projects have made significant contributions to our knowledge of disaster recovery.

Frederick Bates at the University of Georgia completed a study on long-term recovery from the 1976 Guatemalan earthquake, paying particular attention to lessons that could be learned in preparing for similar destructive earthquakes in this country.

Rocco Caporale of St. John's University initiated a major field study on reconstruction and recovery following the 1980 Italian earthquake and the implications of this experience for vulnerable areas in the United States.

Peter Rossi and his colleagues at the University of Massachusetts completed the first nationwide study of disaster victimization. This study, along with a complementary one completed by Robert Bolin of New Mexico State University, provides the first comprehensive view of persons effected by natural disaster, how well they recover and the role of public and private disaster relief agencies in facilitating disaster recovery.

Additionally, a series of case studies completed by Claire Rubin at the Academy for State and Local Government provides the first comparative perspective of the experiences of local governments in both large and small communities in recoverying from disaster. While Rubin's work focuses on such disaster agents as floods and hurricanes, the findings also have implications for handling recovery problems following disasters caused by earthquakes.

In 1969 a NAS committee, chaired by Dr. George Housner of the California Institute of Technology, conducted a study "earthquake engineering research." The resulting document provided a complete evaluation of the status of earthquake effects mitigation capability at that time and made recommendations for future research. Another committee, again chaired by Dr. Housner, has just completed a similar study to assess the progress that has been made, since the 1969 report. The new two volume report is presently being distributed. This report documents the technological and social advancements in all areas of earthquake engineering, identifies needed future research, and recommends appropriate funding levels to continue the progress required to minimize the impact of future earthquakes.

The pressures to constrain Federal budgets have made more important two approaches to gathering information that have been utilized previously in a limited way. These are (1) international cooperative research projects, and (2) acquisition of data from earthquakes and other natural disasters that occur throughout the world. International cooperative efforts with countries that share common seismic problems allow the "pooling" of limited resources to solve a particular problem. We have cooperative research ventures of varying sizes with the People's Republic of China (PRC), Japan, U.S.S.R., Taiwan, India, Indonesia, Italy, Greece, Mexico, New Zealand, Yugoslavia, Turkey, and Peru. Japan and China are of especial interest because each country allocates about 3 to 5 times as much funding for earthquake research as the United States does.

We are presently in the second phase of a very productive cooperative project with the Japanese which includes the testing of large-scale reinforced concrete and steel structures in Japan's unique Tsukuba facilities. Completion of this project will provide valuable data on the size of models required to determine accurately the response of buildings to specific earthquake ground motions. With funding provided by the agency for international development, we have established a joint seminar series with the Japanese to assist developing nations to cope more effectively with earthquake hazards.

A major earthquake anywhere in the world provides a full-scale experiment from which much information can be obtained on the performance of engineered structures and the effects on people. This activity involves the acquisition of critical data on ground motion and structural response for major earthquakes in various countries. Strong motion instrumentation arrays now have been established in six (6) of the most seismically active areas of the world, where there is a high probability of "capturing" an earthquake. Such an array in Taiwan has already recorded two large earthquakes, with 36 of the 37 instruments operating during the most recent earthquake.

International activities will be focused further when the United States hosts the 8th world conference on earthquake engineering in San Francisco in 1984.

A number of studies have now been completed on the damaging 1979 Imperial Valley earthquake in California. During this past year, reports on the damage caused by the earlier earthquakes in Algeria, Italy and Greece also were completed and disseminated. These results are presently being studied to improve aseismic design procedures.

Historical records show a long history of frequent destructive earthquakes in the Balkan region of the world. To reduce the death and destruction from future earthquakes in the Balkans a special program has been established under UN-UNIDO to assemble the latest knowledge gained through research into a series of guidebooks and manuals which can be used to reduce risks and improve the performance of new and existing construction subjected to earthquakes. Through this activity, the United States can contribute much information and will receive the advantage of possibly having this information tested by the more frequent Balkan earthquakes and in learning from the research and experience of the most talented researchers in six other countries. The manuals which will result from the program will be made available (in English) to the technical community in the United States. Coordination of this project is being handled by Prof. Toridis of the George Washington University.

Other natural disasters have common characteristics with earthquakes, for example, winds, tornadoes, hurricanes and tsunamis may produce dynamic loads on structures similar to earthquake forces, and therefore we continue to utilize such information. Public reactions to many natural disasters have many common elements and thus much can be learned from such events. During the past year, teams were dispatched to the site of the floods in (January 1982) northern California and the hurricane in Hawaii (November 1982). Reports of these disasters and their impact on society are now in preparation.

As I discussed earlier, we have had a cooperative research program with the Japanese during the past several years. This has utilized the high quality large experimental facilities constructed in Japan, and in the short term this has allowed the United States to move ahead in the earthquake engineering field.

In the problem-focused program within the engineering directorate, future research activities will emphasize the response of geotechnical materials to dynamic forces, large- and full-scale testing to verify and develop new concepts, the inelastic behavior of structures subjected to seismic loads, special instrument arrays in highly seismic areas of the world, the behavior of "low-rise" structures, and the influence of architectural and urban planning of the vulnerability of structures and communities. We will continue research to determine the 3-dimensional behavior of engineering materials and structures in an earthquake environment. We will continue to study the impacts of earthquakes on social and economic community systems and develop procedures that will minimize these impacts.

Thank you Mr. Chairman for allowing me to summarize the activities of the earthquake hazard mitigation program in the National Science Foundation. Significant progress continues to be made in a variety of scientific, engineering and social areas and the research efforts that we are supporting are directly affecting design and mitigation procedures in all parts of the United States.

I will be happy to answer any questions that you or members of the subcommittee may have.

Senator GORTON. Mr. Kammer, we are very happy to see that you made it through the traffic just in time for your part of this panel. As we have said to the others, your full statement will be included in the record. We appreciate your summarizing it and then we will have questions for all of you.

Mr. **Kammer**. Thank you, sir.

I am here to discuss the earthquake hazard reduction efforts of NBS. These activities are conducted in the Center for Building Technology of the National Bureau of Standards.

The national earthquake hazards reduction program resulted from the Earthquake Hazards Reduction Act of 1977. Under this program NBS conducts research to establish performance criteria and develop measurement technology for earthquake-resistant construction.

For example, we have developed test methods and procedures for evaluating the potential of soils to liquefy under earthquake conditions. We also cooperate with other Federal agencies through the National Institute of Building Sciences, professional organizations, model code institutions, State and local building departments to develop, test, and improve model seismic design and construction provisions.

We have worked with the Interagency Committee on Seismic Safety and Construction to develop a uniform Federal provision for seismic design, which was published in 1981. We have also assisted the Building Seismic Safety Council in developing tentative seismic safety provisions and planning a trial design program to evaluate these provisions.

In fiscal year 1983, NBS as a whole is operating at an annual rate of about $117.8 million. The proposed budget for fiscal year 1984 includes a cost-of-living increase of approximately $6 million and decreases of approximately $25 million. In 1984 the Center for Building Technology is proposed to be abolished. This is reflected in the 1984 budget as a reduction of $3.2 million.

Included in this is a reduction of $475,000 for NBS earthquake efforts. The discontinuation of this program is in concert with the administration's policy of disengaging the Federal Government from areas of State and local responsibility.

The construction industry, in cooperation with the State and local building code authorities, can take a more active role in supporting building technology research. Moreover, the Federal Government will maintain a significant presence in the seismic design and engineering efforts through the programs of FEMA and NSF.

Thank you, sir.

[The statement follows:]

STATEMENT OF RAYMOND G. KAMMER, DEPUTY DIRECTOR, NATIONAL BUREAU OF STANDARDS, U.S. DEPARTMENT OF COMMERCE

I am here to discuss the earthquake hazard reduction activities of the National Bureau of Standards (NBS). These activities are conducted in the Center for Building Technology (CBT) and are an integral part of the NBS building research program.

NBS role in the earthquake hazards reduction program

The National Earthquake Hazards Reduction Program (NEHRP) resulted from the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124). Through this program NBS conducts research to establish performance criteria and develops measurement technology for earthquake-resistant construction. For example, we developed consistent and uniform techniques for conducting a standard penetration test for soils and are experimenting with ways acoustic instrumentation can be used during the test to obtain additional information. We also developed a new design procedure for predicting when soil liquefies.

We assist and cooperate with other Federal agencies, the National Institute of Building Sciences, professional organizations, model code groups, and State and local building departments to develop, test, and improve model seismic design and construction provisions suitable for incorporation in local codes and standards. We worked in conjunction with the Interagency Committee on Seismic Safety in Construction (ICSSC) to develop a uniform Federal provision for seismic design which was published in 1981. We also assisted the Building Seismic Safety Council (BSSC) in developing tentative provisions and planning a trial design program to evaluate the provisions.

In addition, we have been assigned responsibility for developing seismic design and construction standards for application in Federal construction as part of the Priority Federal Programs.

Fiscal year 1984 budget

For fiscal year 1983, NBS is operating at an annual rate of $117,861,000. The proposed budget for fiscal year 1984 includes an increase for cost of living of $5,908,000 and decreases totaling $25,069,000 and 179 positions for programs supported by direct appropriation. The net reduction from the fiscal year 1983 level is $19,161,000.

The budget for NBS reflects the Administration's policy of supporting basic research, particularly in the areas of physical sciences and engineering. The budget for fundamental measurement sciences related to these areas has remained intact.

The Building Technology program contributed to the development of safety codes, an area that has traditionally been within the purview of State and local governments. In addition, significant benefits accrue to the construction industry in the form of reduced construction costs. The discontinuation of this program is in concert with this Administration's policy of disengaging the Federal Government from areas in which State and local governments have unchallenged responsibility. It is reasonable to expect the construction industry, in cooperation with State and local building code authorities, to take an active involvement in supporting this research, perhaps through the auspices of the National Conference of States on Building Codes and Standards (NCSBCS).

This concludes my formal statements. I will be pleased to answer any questions you may have.

[Attachment]

NBS ACCOMPLISHMENTS IN EARTHQUAKE HAZARDS REDUCTION

Earthquake investigations

NBS has a long history of involvement in earthquake research activities. Beginning in 1969, we assisted the State Department in establishing a Subpanel on Wind and Seismic Effects of the United States-Japan Panel on Natural Resources. To determine needs for improved seismic design and construction and for research in this area, we investigated large scale earthquakes in San Fernando, California (1971); Managua, Nicaragua (1972); Romania (1977); Miyagi-ken-oki, Japan (1978); and Imperial County, California (1979). We worked in cooperation with other Federal agencies and the Earthquake Engineering Research Institute in conducting these investigations.

Accomplishments in research

The earthquake program includes strong laboratory-based research activities that strengthen our contributions and participation in the development of improved design criteria. Our geotechnical scientists are conducting research on improved measurements for site evaluation and improved techniques for evaluation of the potential for soils to liquefy during earthquakes. We have continued work on improving existing techniques for site evaluation. Two proposed standards based on this research are currently being considered for adoption by the American Society for Testing and Materials (ASTM).

We have recently completed the construction of a computer-controlled three-dimensional testing facility for structural research. This unique facility is currently being used in studying the basic energy absorbing mechnisms and strength of masonry shear walls subjected to seismic loading. We are beginning work on large-scale bridge columns which will extend our understanding of the performance of very large scale structures and will provide data that are not currently available. We will examine both full-scale ductility and the effect of scale factors on test results to determine if research conducted on small-scale specimens can be safely extrapolated to sizes actually used in bridges. This work is being supported by NBS, the Federal Highway Administration, the National Science Foundation (NSF), and the California Transportation Department.

Accomplishments in seismic design and construction practices

NBS provides technical support to the Federal Emergency Management Agency (FEMA), the lead agency responsible for coordinating the National Earthquake Program. This includes participation on the Interagency Committee on Seismic Safety in Construction and the Building Seismic Safety Council, as well as contributing to the planning of earthquake-related Federal research.

The Interagency Committee on Seismic Safety in Construction (ICSSC) was formed in 1978 by FEMA to develop guidelines for reducing earthquake hazards for use by Federal agencies involved in construction. We have provided technical support to this Committee since its inception including contribution of the acting chairman from September 1981 to December 1982 and the chairman beginning in December 1982. During this period we reaffirmed the agency membership and streamlined the technical subcommittee structure. The ICSSC met in December 1982 and is meeting again on March 10. It is currently reviewing a draft seismic standard for Federal buildings that was developed in 1981 by an ICSSC subcommittee chaired by NBS and is now preparing a similar document for existing buildings. It also is addressing the areas of lifelines, site hazards, and Federal policies for grant, lease and assistance programs.

NBS, FEMA, and concerned groups of the building community worked together to help establish the Building Seismic Safety Council (BSSC) in April 1979. The objective of the BSSC is to provide a national forum to promote the development of seismic code provisions suitable for use throughout the United States. The Council's first specific task was to review the Tentative Provisions for the Development of Seismic Regulations for Buildings that were developed in an NBS-Applied Technology Council project in the 1970's.

At the request of the BSSC, NBS provided technical support for the review. With financial support from FEMA, we worked with approximately 50 organizations from throughout the United States to review and improve the Tentative Provisions. In 1981, we published 11 reports for the BSSC which provided the basis for proposed refinements to the Tentative Provisions.

The Council is undertaking an evaluation of the amended Tentative Provisions by a phased trial design program that is funded by FEMA. Phase I, which is in progress, includes designs of 26 buildings in four cities. Phase II, which will conclude the trial designs, is being planned now. Phase III will include the recommendations of the BSSC for seismic design. We are now providing technical support for the BSSC Trial Design Overview Committee including the joint preparation of two reports.

International activities

Through participation on the Subpanel on Wind and Seismic Effects of the U.S.-Japan Program on Natural Resources, NBS and NSF have encouraged the formulation of a cooperative program on large-scale structural research. With funding from NSF, research is now underway in Japan on steel structures and will begin shortly in the United States. Laboratory work on the seismic resistance of reinforced concrete structures is complete.

NBS provides the U.S. Representative to the International Council on Building Research. His efforts have led to the establishment of an international working commission on earthquake hazard reduction which is chaired by a representative of NSF. We also have a cooperative program with the French national laboratory for building research (Centre Scientifique et Technique du Batiment) on seismic repair and retrofit of existing buildings.

Senator **Gorton**. Thank you, Mr. Kammer.

While I know the witnesses realize that this is not one of the more controversial hearings which either this committee or the Congress will conduct this year, I should like to say that it does have a special interest to me. About the time of the passage of the Earthquake Hazards Reduction Act of 1977, I chaired a committee of the National Association of Attorneys General, which I suspect you all may have funded, to study the legal implications of earthquake prediction and the ways in which states respond.

I found that to be a most interesting study, covering many of the areas you have briefly outlined here today. I am quite interested in the work in which each of your agencies is engaged, and I will, in a sense, follow up on some of the things I learned then and try to gain some understanding from you as to what has happened since I was involved in that activity.

I think I will start with you, Dr. Peck. Is the $5 million cut proposed for your 1984 budget likely to substantially delay the time by which we can have an operational prediction capability in southern California and in my home area of Puget Sound?

Dr. PECK. It may delay. About two-thirds of that cut will be directed toward long-term theoretical and laboratory studies. In any area of research like that, it is hard to say when you get the payoff, but it could delay the development of the understanding that would lead to the ability to put in an operations system.

Partly, we will be assessing the cut against the operational systems, thinning them out. This may not slow things down in part because once you have had the stations in for a few years and develop an understanding, then you can selectively withdraw stations.

Also, during the current year with the increased funds provided for the program by Congress we will be doing some installation of strain meters and seismometers in dole holes along some of the faults like the San Andreas fault that will hopefully increase our understanding of the phenomenon.

Senator GORTON. For both you and Dr. Sanderson and either of the other witnesses who wish to respond, is this an area in which the Japanese, who obviously have a great interest in this subject, are substantially ahead of us, both in prediction research and in research in other areas? If it is, to what extent is the work which they have accomplished available to and useful to us here in the United States?

Dr. PECK. Let's see. I can say a couple of things relevant to that. One is that as far as the exchange of information, we have had a very close, collegial relationship with the Japanese in both earthquake and volcano research for several decades, and the research results that we find, we exchange with our colleagues, and they do the same.

They have had a major program for some 20 years on earthquake prediction and have a truly operational network in part of Japan. I don't think as far as an understanding, that they are ahead of us, but they do have an operational network.

Senator GORTON. They don't have any greater predictive capability?

Dr. PECK. In the one area where they have the operational network, they may have more capability. It might be worthwhile—I have with me Dr. John Filson, director of our earthquake studies program. He may want to add some comments to that.

Senator GORTON. I would be happy to hear from him.

Dr. FILSON. In the scientific understanding of the earthquake prediction problem, the Japanese are not ahead of us. We have, in addition to the collegial exchanges Dr. Peck mentioned, a formal agreement to exchange information on an annual basis, specifically on earthquake prediction, with the Japanese.

The Japanese are currently spending approximately $30 million a year on earthquake prediction-related work and have heavily instrumented an area south of Tokyo called the Tokai Peninsula. In that area they may have, because of the dense instrumentation, an enhanced earthquake prediction capability.

Senator GORTON. Thank you.

Dr. Sanderson.

Dr. SANDERSON. It is important to realize that as a nation Japan is even more threatened by seismic risk than the United States. As a result, they have a substantial research program in areas relating to earthquake hazard mitigation. Fortunately, we have been able to collaborate with the Japanese on this, and as I mentioned in my testimony, we have a number of joint projects under way using unique facilities which they have constructed.

In terms of leadership, it is a very difficult question to answer. Clearly, I believe that in terms of technical understanding, in terms of the ability to model, to understand what is going on in many ways we are at least their equal, perhaps somewhat ahead.

In terms of experimental activities, the Japanese have benefited from several years of major investment in large-scale facilities. And fortunately, with a few exceptions—we have been able to collaborate with them on a free and open basis in terms of experimental projects.

There is a problem of international perception which I have noticed over the past few years, particularly in dealing with countries around the Pacific rim which are also at seismic risk, the Japanese are now viewed as being in perhaps a better position to supply engineering and scientific services to those countries than some of the American scientists and engineers because the availability of large and unique experimental facilities give them a great deal of international visibility.

Senator GORTON. Thank you.

Dr. Peck, if we were able to develop a reasonably accurate short-term prediction system in the next half dozen years or so, would the States be in a position to respond in time to such predictions in ways which would substantially reduce casualties and economic losses?

Dr. PECK. Certainly, in California I think we made a good deal of progress over the last several years through several efforts, in part, sponsored by FEMA, by the State office of emergency services, including sort of dry runs of earthquakes and also some collaborative work by the California Bureau of Mines and Geology, working on implications of an earthquake and what facilities would be damaged and what transportation routes would be disrupted.

So I know that, yes, there is a good chance that in the next 5 or 10 years we would be there.

Senator GORTON. Mr. McLoughlin, can you respond to that question as well? And would FEMA be able successfully to utilize that kind of predictive ability?

Mr. MCLOUGHLIN. We have been working, as you know, with the southern California people and have been putting money into their preparedness planning efforts. Clearly, the first efforts from our standpoint are with respect to the actual response to the event itself and then from the standpoint of the prediction response also.

With respct to the Federal response in supporting State and local governments, again our priorities have followed the same lines. As

I said earlier, we expect to have published in the March Federal Register the planning guidance for the development of the Federal response plan which would be used in the interim for response planning. And we next plan to turn our attention to the prediction response planning.

Senator GORTON. This one is for Dr. Sanderson and for Mr. Kammer, two sides of the same coin. If the administration is successful in eliminating NBS's earthquake program, what plans, Mr. Kammer, are there to transfer it to other agencies? And, Mr. Sanderson, is NSF able to take any of it over?

Mr. KAMMER. Sir, there are no plans at the moment to transfer it to another agency. Our program at $475,000 is not particularly large in comparison to the Federal effort. If other people wanted access to our facilities, we would make them available on a reimbursable basis.

Dr. SANDERSON. Mr. Gorton, as I said in my statement, we have no plans to take over, using your phrase, any of the activities of the National Bureau of Standards. However, we are moving to strengthen our ties with the State and local officials, and particularly with the private sector, so that the communication channels between the research community and the ultimate user community will remain in place and strong. For example, about 10 percent of my awards in this program now go to small business firms in the United States, small consulting engineering firms, and research firms of one sort or another. We will be strengthening this type of activity to provide more direct communication.

Senator GORTON. Thank you.

Mr. McLoughlin, I think it is appropriate to compliment FEMA on an increasing attention and commitment to this area. We still, of course, are concerned with the missing 5-year program plan which was due approximately a year and a half ago. We understand now that it is almost complete.

Can you tell us when Congress is going to get it and whether it will include an implementation schedule and recommendations and how it will be updated and the like?

Mr. McLOUGLIN. Senator Gorton, we are aware that we are late with this, and we thank you for your comments. And we have made some significant strides, I think, within the last 12 months.

But Mr. Steinbrugge and his panel of experts have indeed been meeting in full committee a number of times and in executive session an additional number of times. We are expecting their report to us in the next few weeks. We expect to be able to send their plans to the Congress within the next 60 to 90 days.

We hope to endorse this and plan to take our lead agency role in terms of its implementation responsibilities. And if there are any substantial differences, which we clearly do not expect, based on our initial discussions, we would so advise the Congress at that time.

Senator GORTON. Thank you. As you know, GAO has just issued a draft report on the earthquake hazards reduction program and claims that FEMA has not carried out certain functions for which it is responsible. Do you believe that you have the authority to carry out these functions and that you should do so, or should the Congress revise the law in some respect?

Mr. **McLouglin**. I have read the interim draft report from the GAO, Senator. And while I am not prepared to comment on it in detail right now, we do clearly believe that FEMA should have, and has, the capability and the authority to address the lead Federal agency role. I think we have made substantial strides in executing that responsibility over the last 12 months. We believe that the most appropriate role for us is a collegial, a supportive and coordinated one with the other three agencies that are represented by the panel members here.

During the last year, on at last four separate occasions, policy representatives from each of the four agencies have met to consider major issues so that not only are issues being addressed at the technical level among our staffs, but they are also being addressed at the political policy level.

Senator **Gorton**. So I take it that to the extent that the GAO report raises the question as to whether FEMA should serve as the coordinator or manager of the earthquake reduction program, you see yourself as the head of this collegial effort?

Mr. **McLouglin**. That is correct.

Senator **Gorton**. In your testimony you state that FEMA has established an earthquake policy group. Could you explain what you see its role to be and how often you would meet and what issues you expect the group to take up during 1983?

Mr. **McLouglin**. Lee Thomas, who is the associate director for State and local programs and support in our agency, initiated it to set up policy meetings with Dr. Peck and representatives of other agencies. The group has met together on about four separate occasions.

We try to address major issues including the 5-year plan, and we are considering right now whether or not we should formalize the institution of the policy level committee with the publication of a Federal Register notice. We have not completed discussions with the other agencies on that consideration.

With respect to the last part of your question on issues that the policy committee may address, I simply am not prepared to address those issues because we have not discussed them in depth with the other agencies.

Senator **Gorton**. I thank you, Mr. McLoughlin. I thank the balance of the panel as well for helpful and enlightening testimony.

Our next witness will be Mr. Lowell Dodge, from the Community and Economic Development Division of GAO.

Mr. Dodge, would you introduce your two colleagues and proceed with your statement, also on the understanding that your entire written statement will be included in the record, and we would appreciate your summarizing.

STATEMENT OF LOWELL DODGE, ASSOCIATE DIRECTOR, RESOURCE, COMMUNITY AND ECONOMIC DEVELOPMENT DIVISION, GENERAL ACCOUNTING OFFICE, ACCOMPANIED BY RON WOOD, GROUP DIRECTOR; AND LOUIS SCHUSTER, EVALUATOR

Mr. **Dodge**. Thank you, Mr. Chairman. On my left is Ron Wood, who is the group director in charge of evaluating FEMA's disaster assistance activities. And on my right, Louis Schuster, who captained this particular GAO review.

We welcome your invitation to discuss our review of progress in implementing the Earthquake Hazards Reduction Act of 1977, as amended. This review is aimed primarily at assessing how well the Federal Emergency Management Agency is carrying out its lead role under the act.

In summary, Mr. Chairman, our draft report indicates that despite some progress since mid-1981, implementation of the act has fallen behind schedule. FEMA has not carried out several provisions and has missed deadlines on others. We believe FEMA should nonetheless remain lead agency because of its primary disaster assistance role in the event of a major quake.

In furtherance of the act's objectives, FEMA should, however, we think put in place an interagency mechanism for planning, budgeting, and evaluation to guide the Federal agencies participating in the program.

My testimony today will address four subjects, as listed in my prepared statement, Mr. Chairman, and following your suggestion, I will summarize our findings.

As you know, in 1977 the act that was passed sought to establish a national earthquake hazards reduction program under which the efforts of Federal, State, and local governmental units and private organizations concerned with earthquake hazards would be jointly planned and coordinated. Then after FEMA began its operations in 1979, Congress amended the act, designating FEMA as "the agency with primary responsibilities to plan and coordinate the earthquake program."

In 1982 the President issued an Executive order delegating to FEMA the functions assigned to the President under the 1977 act and under its 1980 amendments. And this delegation had the effect of making FEMA responsible for performing certain functions itself rather than recommending them to the President for him to execute.

The 1977 act and this 1982 Executive order, taken together, impose a very specific set of requirements on FEMA. FEMA is to assign roles and responsibilities to each appropriate agency as a part of the earthquake program; to set goals, priorities, budgets, and target dates for the overall program; to compile the written multiyear program plan, as you discussed earlier in the hearing; to submit an annual report to Congress within 90 days after the end of each fiscal year, evaluating progress achieved during the year; and FEMA is to provide qualified and sufficient staffing for the program.

In our view, Mr. Chairman, these requirements amount to a charge to FEMA to establish an integrated management system for the entire program, including staffing and the development of priorities and budgets and the performance of program evaluation.

How well has FEMA performed these requirements? FEMA officials view their lead agency role as evolving over time. Initially, FEMA defined its role narrowly, functioning as a coordinator rather than as a leader or as a manager, and generally left management decisions associated with planning, budgeting, and evaluation to each agency to determine for its own earthquake activities.

Since mid-1981 FEMA has stepped up the pace of earthquake program activities. And its officials would now like to assume a more aggressive role, but have stated to us that they believe they may not have sufficient authority.

FEMA's limited view of its lead role has affected its performance. Prior to the 1982 Executive order, FEMA had not made recommendations to the President concerning the roles and responsibilities of the various agencies or on the goals, priorities, budgets, and target dates for the implementation of the program as mandated by the act.

And following the Executive order, FEMA was to assign these roles and set goals, priorities, budgets, and target dates on its own, but to date has not done so. Nor has FEMA completed work on the multiyear program plan, as I believe you have sufficiently covered already this morning.

FEMA has produced only one annual report since 1979, the year that the President delegated this task to FEMA. FEMA has not provided qualified and sufficient staffing for the program. And with respect to this point, Mr. Chairman, what we think is essential here is the idea of a staff which is dedicated to the program as a program. FEMA does have staff members working on its own earthquake programs, but has not committed staff specifically to work on the interagency aspects of the program. And that we feel is a major element which is lacking.

FEMA began taking steps to implement the program in 1981. FEMA officials point to a group established in late 1981, the Interagency Coordination Committee of the national earthquake hazards reduction program. However, we found that this committee does not function as a mechanism for achievement of the integrated national earthquake program.

More recently, FEMA has established, as mentioned in its statement, a high-level policy group intended to take actions to meet the Earthquake Hazards Reduction Act's requirements for the establishment of goals, priorities, target dates, and an integrated national program. This group, which was chaired by FEMA at the level of the associate director of the agency, has met three times to date, but it is too early to tell whether this group will meet FEMA's expectation that it will become the operative interagency mechanism of the program.

Our review did identify a number of factors which may have affected FEMA's rate of progress in implementing the program. The first is the belief, expressed to us by FEMA program officials, that FEMA lacks sufficient statutory authority to implement its assigned lead role responsibilities, such as initiating an interagency budget process.

We list three other factors in our statement, Mr. Chairman, of lesser significance. However, I would like to address for just a moment the question of authority, if I may.

The assertion that FEMA may lack authority to carry out its lead role in the new earthquake program is one we heard only from FEMA program officials. Their doubts seem to focus on the issue of whether FEMA can control, direct, or otherwise influence the actions of other agencies.

On this question, we would observe, however, that granting FEMA more control than it is already authorized to exert over the actions of other agencies under the act and the Executive order may not be essential to a viable earthquake hazards reduction program. Our review noted that there is no shortage of models for effective interagency cooperative arrangements, many of which extend to joint agreement on budgets and priorities. And these arrangements can work without granting any one agency the power to control the decisions of another.

An example is the interagency program addressing the acid rain problem, which has, we might note, implemented a consolidated budget process.

Senator GORTON. If I may interrupt there, I take it that what your written report raised is the question as to whether FEMA's authority as lead agency is adequate. You really believe that it is?

Mr. DODGE. We do believe that it is, yes, to do what they need to do to carry out the program as a coherent program.

Now, with respect to the goal of an earthquake prediction system, we would note that the question of how much priority to assign to the development of a prediction system is one which FEMA and other agencies, particularly the U.S. Geological Survey, might usefully address jointly in the course of interagency deliberations.

The expectation in 1977, when the act was passed, that the development of an earthquake prediction system could be completed and a prototype put in place, has not materialized. And we have heard the reasons for that explained this morning.

But we would like to underscore that we think the issues raised by the prediction system, including whether it should be pushed harder and whether the funding should be increased, are precisely the kinds of issues that we think ought to be subjected to a broader interagency review of greater depth than we have had to date. Such a review is one which FEMA might, as lead agency, initiate.

So, in short, while FEMA has taken initial steps, including the establishment of a high-level interagency policy group, toward more fully developing its lead agency role, we believe that FEMA could substantially improve its performance simply by more diligently performing the requirements of the act, including taking an active role in assigning specific responsibilities to other agencies and taking the initiative on joint interagency consideration of priorities, budgets, and target dates for the program.

We do believe that FEMA can exercise the authority granted to it under the act and under the Executive order to establish an interagency structure, and we believe that this structure should facilitate agreement on priorities and help resolve program issues.

Given the results of our review, Mr. Chairman, we believe that continued interest and oversight by this subcommittee and others can provide important encouragement to FEMA and accelerate the Agency's efforts to establish a more viable national earthquake hazards reduction program.

Mr. Chairman, that concludes my prepared statement, and we would be happy to answer any questions.

Senator GORTON. I take it that that last comment means that you do not think that there needs to be a substantial revision in the statutory distribution of authority in this respect but that any help which this committee or the full committee can provide is of an oversight nature?

Mr. DODGE. That is correct.

Senator GORTON. Is it your view that the program should be authorized for an extended period of time, say, at least 3 years, or only 1 or 2?

Mr. DODGE. Well, normally, the General Accounting Office supports 2- or 3-year reauthorization periods, simply because the effort to prepare for reauthorization on the part of the agencies is so time-consuming and to have to do that each year tends to distract agencies from their substantive mission.

In this case, however, Mr. Chairman, we believe that a 1-year period would be appropriate in view of the limited progress to date by FEMA in implementing its lead agency role and in view of what we believe is the need for this subcommittee and others to maintain very close oversight, such as would be afforded by 1-year reauthorization intervals.

Senator GORTON. Your testimony indicated that FEMA has not dedicated a staff or an office to carry out its lead role responsibilities. I would like to press that a little further. Does FEMA need a larger staff for this? Is a separate staff or an office important to this role, or can it be conducted under its present organizational structure?

Mr. DODGE. In our view, the most important single need is for FEMA to dedicate some level of staff and an office, and, as symbolic as it may seem, but nonetheless important, a phone number to the program—some institutional presence somewhere for members of other agencies, officials at the State level, and persons in the private sector to turn to when they have a question, for example, about what is the priority on one matter or another.

There is no such dedicated office at this point. We think the size of that office is less important than its existence and believe that its size should flow more from the role that it develops after it comes into existence.

But we do believe that the existence of a dedicated staff would make a critical difference in future progress in implementing the program.

Senator GORTON. Mr. Dodge, I thank you for your appearance here today and for your sharp and incisive comments, and for the report as well.

Mr. DODGE. Thank you.

[The statement follows:]

STATEMENT OF LOWELL DODGE, ASSOCIATE DIRECTOR, RESOURCES, COMMUNITY AND ECONOMIC DEVELOPMENT DIVISION, GENERAL ACCOUNTING OFFICE

Mr. Chairman and members of the subcommittee, we welcome your invitation to discuss our review of progress in implementing the Earthquake Hazards Reduction Act of 1977, as amended. This review was aimed primarily at assessing how well the Federal Emergency Management Agency (FEMA) is carrying out its lead role under this act.

A draft of our report is now with FEMA and other affected agencies for their review and comment and is subject to revision based on comments received. My statement here today will highlight the findings contained in the draft report and offer our views on ways to improve the implementation of this act.

In summary, Mr. Chairman, our draft report indicates that despite progress since mid-1981, implementation of the act has fallen behind schedule. FEMA has not carried out several provisions and has missed deadlines on others. We believe FEMA should nevertheless remain lead agency because of its primary role in the event of a major earthquake. In furtherance of the act's objectives, FEMA would be well advised to put in place an interagency mechanism for planning, budgeting, and evaluation, to guide Federal agencies participating in the program.

My testimony today will address the principal requirements of the 1977 act, as amended; FEMA's progress in implementing these requirements; factors which have limited FEMA from fully complying with the act; and the status of earthquake prediction efforts.

THE NATIONAL EARTHQUAKE HAZARDS REDUCTION ACT OF 1977 AND THE EXECUTIVE ORDER OF SEPTEMBER 1982

The 1977 act sought to establish a National Earthquake Hazards Reduction Program, under which the efforts of Federal, State, and local governmental units and private organizations concerned with earthquake hazards reduction would be jointly planned and coordinated.

The act assigned to the President the development of a plan for implementing the new earthquake program. This plan, presented to the Congress in 1978, set forth principles to guide the program and proposed in general terms the roles to be played by various involved Federal agencies. Principal among these agencies were the U.S. Geological Survey, the National Science Foundation, and the National Bureau of Standards. The plan did not specify or recommend any particular organizational structure or management system for the program, except to state that a lead agency should be designated to provide "a central focus" for coordinating the program, and to list certain functions for the lead agency.

After FEMA began operations in 1979, the Congress amended the act, designating FEMA as "the agency with primary responsibilities to plan and coordinate the National Earthquake Hazards Reduction Program." The Congress stopped short of mandating that FEMA direct or "conduct" the program, as initially proposed in the 1980 House bill. Instead, FEMA was to offer a set of recommendations to the President. The President was then to assign roles to the appropriate agencies and to set goals, priorities, budgets, and target dates for the program.

In 1982, the President issued an Executive Order delegating the FEMA the functions assigned to the President under the 1977 act, as amended. This delegation has the effect of making FEMA responsible for performing important functions itself, rather than recommending them to the President for him to execute.

The 1977 act, as amended, and the 1982 Executive Order require FEMA to assign roles and responsibilities to each appropriate agency as a part of the earthquake program (delegated by the Executive Order); establish goals, priorities, budgets, and target dates for the implementation of the program (delegated by the Executive Order); compile a written multi-year program plan to have been completed by September 30, 1981, transmit it to the Congress, and update it annually; submit an annual report to the Congress within 90 days after the end of each fiscal year, evaluating progress achieved during the preceding year in reducing earthquake risks, and include a copy of the multi-year program plan, (delegated by the Executive Order); and provide qualified and sufficient staffing for the program.

These requirements amount to a charge to FEMA to establish an integrated management system for the earthquake program, including staffing, the development of priorities and budgets, and the performance of program evaluations.

FEMA'S PERFORMANCE UNDER THE ACT

FEMA program officials view their lead agency role as evolving over time. Initially, FEMA defined its role narrowly, functioning as a coordinator, rather than as a leader or a manager. It has generally left management decisions associated with planning, budgeting, and evaluation to each agency to determine for its own earthquake activities. Since mid-1981, FEMA has stepped up the pace of earthquake program activities. FEMA's program officials would now like to assume a more aggressive role, but believe they may not have sufficient authority.

FEMA's limitation of its lead role to that of coordinator has had an impact on its performance of the requirements assigned to it under the act. Prior to the 1982 Executive Order, FEMA had not made recommendations to the President concerning the roles and responsibilities of the various agencies or the "goals, priorities, budgets, and target dates for implementation of the program," as mandated by the act. Following the Executive Order, FEMA was itself to assign these roles and set the goals, priorities, budgets, and target dates for the implementation of the program. To date, FEMA had not done so.

Nor has FEMA completed work on a multi-year program plan. This plan was to have been transmitted to the Congress by September 20, 1981, and updated annually. Now, 17 month after that date, the plan is in draft form and yet to be issued. FEMA has created an independent panel of experts to review the draft; this panel is still at work. Our review of the current draft ("Review Panel Draft, September, 1982") notes that the plan lacks elements we believe to be essential to a complete program plan, including a delineation of goals, priorities, timetables, and a consolidated program budget.

FEMA has produced one annual report since 1979, the year the President delegated this task to FEMA. The report, which covers fiscal year 1981, consists largely of descriptions of the activities of the U.S. Geological Survey, the National Science Foundation, the National Bureau of Standards, and other agencies. It does not include an evaluation of progress in implementing the earthquake program, as specified in the law. Nor does it include a copy of the multi-year program plan, as required, since FEMA has not issued that plan. FEMA officials state they are now completing work on the annual report covering fiscal year 1982, which was due to the Congress by December 31, 1982.

FEMA has not provided qualified and sufficient staffing for the program. We found that only one FEMA staff member spends a substantial amount of his time on FEMA's lead role responsibilities under the act. This person is a staff assistant reporting to an official who is three organizational levels below the Director of FEMA. The three officials in line above this assistant each spend smaller portions of their time on the earthquake program, which competes for their attention with numerous other functions for which they are also responsible. Ten or so employees in other parts of FEMA are also engaged in earthquake related activities, such as assisting State and local units of government, but are not a part of the effort to establish and lead an interagency program.

FEMA began taking steps to implement the National Earthquake Hazards Reduction Program in 1981. FEMA program officials point to a group established by FEMA in late 1981, the Interagency Coordination Committee of the National Earthquake Hazards Reduction Program. This committee is described in the program's Annual Report for 1981 as its "formal coordinating mechanism." It is composed of mid-level representatives of the major agencies concerned with earthquake hazards reduction and has met on a quarterly basis. Its charter limits its functions to coordinating the activities of participants, and also advising FEMA.

Our review of this committee's efforts indicates that the committee has not addressed the establishment of the "goals, priorities, budgets and target dates" for the implementation of the National Earthquake Hazards Reduction Program. It is accurately described in the program's most recent annual report as an institutionalization of ad hoc but longstanding informal relationships among various concerned officials. In short, this committee does not function as a mechanism for the achievement of an integrated national earthquake program.

FEMA has also recently established a high level "policy group" intended to take actions to meet the Earthquake Hazards Reduction Act's requirement for the establishment of goals, priorities, budgets, and target dates for an integrated national earthquake program. This group, which is chaired by FEMA, at the level of Associate Director of the agency, has met twice to date. It is too early to tell whether this group will meet FEMA's expectation that it become the operative interagency mechanism of the earthquake program.

FACTORS AFFECTING FEMA'S PERFORMANCE

Our review identified a number of factors which may have affected FEMA's rate of progress in implementing the program. The first is a belief, expressed to us by FEMA program officials, that FEMA lacks sufficient statutory authority to implement assigned lead agency responsibilities, such as initiating an interagency budget process. I will return to this concern below.

Three other factors which may also have contributed are: delays by FEMA arising out of "start-up" problems it has experienced as a relatively new agency; FEMA's lack of technical in-house expertise; and the view, held by some in FEMA and elsewhere that the existence of numerous channels of informal communication within the "earthquake community" makes it unnecessary to dedicate staff or an office to manage the earthquake program.

With respect to start-up problems, FEMA has existed for nearly four years and can no longer be considered a newborn agency. Concerning staff expertise, FEMA has not taken sufficient advantage of existing opportunities for obtaining expert assistance, including requesting other agencies to detail needed staff, or establishing a standing technical committee. With regard to reliance on informal communications, FEMA recently has acknowledged that dedicating a staff and an office to the earthquake program may have merit.

FEMA'S RESPONSIBILITY FOR THE PARTICIPATION OF OTHER AGENCIES IN THE PROGRAM

Our review indicates that FEMA, rather than any other agency, should serve in the lead agency role in the earthquake program. In this regard, FEMA has primary responsibility to take action, if called upon to do so by the President, in the event of a major quake. Such a responsibility, in our view, logically leads to retaining FEMA as the general focal point of earthquake preparedness activities.

The assertion that FEMA may lack sufficient authority to carry out its lead role in the new earthquake program is one we heard only from program officials in FEMA. Their doubts focused on the issue of whether FEMA can control, direct, or otherwise influence the actions of other agencies. On this question, we would observe, however, that granting FEMA more control than it is already authorized to exert over the actions of other agencies may not be essential to a viable earthquake hazards reduction program. Our review noted that there is no shortage of models for effective interagency cooperative arrangements, many of which extend to joint agreement on budgets and priorities. These arrangements can work without granting any one agency the power to control the decisions of another. An example is the interagency program addressing the acid rain problem, which has implemented a consolidated budget process.

In its lead agency role, FEMA has not been resourceful in using its existing authority to shape an interagency management system or structure in which other agencies might participate willingly, even on questions related to budgets and priorities. FEMA's day-to-day effectiveness could rest on its exercise of its responsibility under the act to monitor the progress of other agencies' activities (for the purpose of preparing the annual report for the program) and on its leadership in the joint effort to produce and update the statutorily required multi-year program plan.

LACK OF ACTION ON AN EARTHQUAKE PREDICTION SYSTEM

The question of how much priority to assign to the develpment of an earthquake prediction system is one which FEMA and other agencies, including the U.S. Geological Survey, might usefully address jointly in the course of interagency deliberations. The expectation in 1977 when the act was passed that development of an earthquake prediction system could be completed, and a prototype put in place, has not materialized. Currrent monitoring systems in place in California may produce warnings, but not firm predictions. To upgrade these monitoring systems to prediction systems would involve the application of complex measurement technology and computer modeling. An investment estimated at $60 to $100 million or more for an earthquake hazard zone would be required. Considerable uncertainly exists about the prospects for a reliable operational prediction system even if large sums are invested.

The view is held by some scientists that current funds would be better spent on basic research to increase knowledge of earthquake phenomena, to improve our ability to measure them, and to develop better ways of evaluating the data collected. However, because the probability of earthquakes in some areas is relatively high, and potential losses large, planning by the U.S. Geological Service for a prototype prediction system continues.

The issues of whether the effort to develop an operational prediction system should be pushed harder and whether its funding should be increased remain unrevolved. These issues might benefit, as suggested above, from being subjected to a broader, interagency review, such as one which FEMA as lead agency might initiate.

THE NEED FOR IMPROVED IMPLEMENTATION OF THE ACT

FEMA has taken initial steps, including the establishment of a high level interagency policy group, toward more fully developing its lead agency role in the National Earthquake Hazards Reduction Program. We believe FEMA could strengthen its lead role substantially simply by excecuting more diligently the requirements of the act, including taking an active role in assigning specific responsibilities to other agencies, and taking the initiative on joint interagency consideration of priorities, budgets, and target dates for the program.

We believe FEMA can exercise the authority granted to it under the act and the 1982 Executive Order to establish an operative interagency structure. This structure should facilitate agency agreement on priorities and resolve program issues.

Given the results of our review, we believe that continued interest in oversight by this subcommittee and others could provide important encouragement to FEMA, and accelerate the agency's efforts to establish a more viable National Earthquake Hazards Reduction Program.

Mr. Chairman, that concludes my prepared statement. I would be happy to address any questions the subcommittee might have. Thank you.

Senator GORTON. The final witness in this hearing this morning is Dr. Karl Steinbrugge from the Earthquake Review Panel of FEMA in California.

Doctor, as is the case with the other witnesses, your entire written statement will be included in the record, and as a vitally important part of what we are attempting to do in this reauthorization process, we would appreciate your summarizing it for us orally.

STATEMENT OF KARL V. STEINBRUGGE, CHAIRPERSON, EARTHQUAKE REVIEW PANEL, FEDERAL EMERGENCY MANAGEMENT AGENCY

Mr. STEINBRUGGE. Thank you, Mr. Chairman.

I am pleased to appear before this committee and discuss the national earthquake hazards reduction program as chairman of an independent review panel for that program.

The panel started last October, and very quickly, while we were volunteers, we took the task very, very seriously. In the first meeting in October, when we reviewed the draft that had been prepared by FEMA and the agencies and that was presented to us, we found the general thrust of that draft report to be appropriate, but major sections were unacceptable as to content, emphasis, or style, and being independent, we took our responsibilities very thoughtfully and came back with changes.

The last meeting of the panel was yesterday and the day before. So my prepared remarks are those which I wrote before yesterday's meeting, anticipating what their thinking might be, but clearly stating that they were my opinions.

With your permission, I would now like to state the panel's conclusions, which will differ only slightly in emphasis and add a few more items. Thus, I think the statement will be more current. With your permission, therefore, I would like to speak to the notes I wrote last night.

Senator GORTON. Please do.

Mr. STEINBRUGGE. We wrestled a lot with the 5-year program plan budget. In the real world, one might be realistic as to how much money is devoted to which programs and why. We came up with two levels, or rather, two levels were presented in the draft agencies' plan, a level A and a level B. We examined level A, trying to match everything that we had received from the agencies. When we got through, we thought that level A had generally represented a minimum amount required to sustain the currently projected activities.

In some instances, however, the amounts represented a lower level of activity than what was needed. In other words, in some cases, level A was clearly inadequate. We did not come to that decision easily or soon. We tried very, very hard, asking, "How can we push here? Where do we go there?" So we also have two levels, but level B is the one that we do recommend. That was a unanimous decision.

Those moneys are shown in appendixes to my written statement and I won't bore any of you with how the numbers were derived. Indeed, some of them were added this morning, hopefully correctly. But the levels as given were quite carefully thought through item by item. Two additional appendixes present what our views are on the five program elements and the specific program objectives and tasks.

I think it is perhaps most important that we go to what we consider to be the major issues that we would like to bring to your attention.

One of the issues we believe most important is a relatively small item in a dollar sense, but one with many important features, and that is the postdisaster mitigation studies. Since earthquakes cannot at present be predicted, we cannot use the usual budgetary procedures to ensure funding to send teams to look at specific problems in an area hit by a quake. Consequently we are proposing that a half a million dollars be set aside on a no-year basis to support comprehensive initial field investigations after an earthquake occurs, to be coordinated by FEMA. Maybe coordinated is not quite the right word, when I listen to the testimony of the previous persons here, but it will be the mark of leadership shown by FEMA working with all of the affected agencies and getting these studies started immediately on very perishable items. Debris is cleaned up, light fixtures are quickly removed if they are damaged in falling, so that we must examine these items and understand them, and by understanding them, I mean, do the engineering and scientific analyses quickly and set the right direction for these studies from the very beginning.

I think it is a very, very important thing not only for the sciences but as a leadership role for FEMA. This has been discussed with the agencies. While I do not have approval or disapproval—perhaps those two are the wrong word—it seems to me that this a role that could and must be taken by FEMA.

As for FEMA's role in the earthquake program—well, really, there has been some dissatisfaction among the majority of the panelists regarding FEMA's past leadership role in the earthquake hazards reduction program. I share that dissatisfaction. The original high hopes in the 1978 report of the Working Group on Earthquake Hazards Reduction for the Office of Science and Technology Policy has not been realized. The panel believes that the role FEMA is performing now is being done successfully, at least in a preliminary fashion. However, FEMA's concept of its role is evolving. We strongly urge that there be a continuing advisory panel being the "conscience" of FEMA and also trying to bring together the various agencies. When I say trying to, I think that is perhaps the correct term.

We also believe that this advisory panel should be staffed with highly qualified persons—I do not know how many—in the affected disciplines; in other words, that there is a visible leadership presence there. We are not yet prepared to state what this might or might not be. After all, there are only so many hours we can spend and still meet the requirements of our panel's responsibilities.

We believe that the word "collegial," which has been used here, is perhaps appropriate, or something similar to it, but we do not believe that the science and the engineering professions and the other strongly motivated groups would prosper under a very strong administration or dictatorial effort.

Moving on to another issue, there is emerging perhaps more clearly now than in 1970, when it was thought of at that time, a national experimental facility or facilities; in other words, the sort of thing mentioned earlier that the Japanese are doing in major testing. The investments could be large in terms of multiples of the earthquake prediction program. On the other hand, the payoffs could be large. Earthquakes do not kill people. It is the buildings that we live in that kill people.

We are recommending that FEMA show leadership here in going to the President's Science Adviser to ask him to impanel a group to resolve this question. I and the panel have done preliminary thinking in this regard, and I have made contacts, and I believe that this is a feasible and practical way of going, and I urge that FEMA take this leadership step.

Information on the proposed elimination of the National Bureau of Standards program in building research came to us very late, so late that I was not able to put it on the agenda that was mailed to the panelists for the meetings for yesterday and the day before. Therefore, they came to the meeting unprepared.

In the interim, I have done enough homework to be able to speak on this subject, but it is unfair to ask a panel to make a decision as to the elimination of a program which in a dollar sense may be very small, but in the real world of building, design and construction in seismic areas is entwined with almost all other aspects of building activities.

For example, life safety during and after an earthquake involves the integrity of stairs, ceilings, and firefighting facilities. One thing that an organization such as the center of building technology of NBS that can do is to conduct these studies in an impartial atmosphere which is different from the private sector—and I come from the private sector—in this sense: that the private sector facilities, many of them are product oriented, so we might have—in one laboratory do magnificent research, but it may be related to concrete. Another laboratory may do just as good work, but it is related to structural steel.

Academia has sometimes a different focus, due to its teaching role. The panel reserved judgment on any final decision on this subject, but they came to the conclusion with respect to the earthquake hazard reduction program that the technical support that NBS provides to FEMA is essential. If this support were to disappear, it is mandatory that FEMA obtain it elsewhere.

I think perhaps I should conclude my remarks, Mr. Chairman, that there has been progress in the earthquake hazard reduction program, but really much still remains to be accomplished to achieve the objectives set by Congress when they passed Public Law 95-124.

Accordingly, it is recommended to this committee that this law be reauthorized for at least 2 years, to allow the program to proceed in an orderly and cost-effective manner.

I was personally going to urge more than three, but I was told, in the real world, "not get too greedy, Karl."

I thank you, Mr. Chairman. If you have any questions, I would be delighted to try to answer them.

Senator GORTON. Thank you very much, Mr. Steinbrugge.

I have heard, of course, a good deal of criticism of both the speed and the decisiveness of FEMA's efforts. It does seem to me, however, and you can certainly comment on this, that it deserves a degree of credit and recognition for giving adequate responsibility to your committee, and I hope that that is a good sign and an indication of a change in FEMA's willingness to accept outside criticism and to try to respond to it.

Do you think you are getting through?

Mr. STEINBRUGGE. I do. I would not continue with the assignment and push the panelists as far as I did. I think the committee, who is truly, truly independent in many ways, would have asked that we fold if we were not successful. I see attendance at committee meetings approaching 100 percent. Those that cannot make it, always have compelling reasons, examplified by a call from overseas from one panelist that got stuck. I am convinced that we are getting through, and convinced that the panel thinks we are getting through.

I do believe that FEMA can do the job. I believe also they have been reorganized a number of times, and none of this helps any program, including earthquakes.

Senator GORTON. In your written testimony, you call for a new program for a national experimental facility or facilities which might cost as much as $350 million. Since that would be a more than significant investment, can you explain why you think it is needed and whether or not either FEMA or OSTP has evaluated the proposal?

Mr. STEINBRUGGE. I cannot speak to whether or not they have. The question did come up, at panel meetings and representatives from agencies mentioned it. We reached a consensus that feasibility studies were needed. In other words, if the Japanese have the facility—and I have seen their static facilities—are the results really worthwhile? Should we duplicate it? And if it turns out to be a white elephant, would we want a $350 million white elephant? If it is good, can we go to the next generation, which is better?

The perception that the Japanese have better facilities is a little ironic in a way, because much of it is a joint United States Japanese project. Why it was placed in Japan is not clear to me, but I am sure there was good reason.

Now, why do I think it is an important program? Why is the Nevada test site good? I mean, why do we have it? It is the same sort of thing. We can go through theoretical analyses, but if what we observe does not always agree with our theoretical analysis, it is not the observation that is incorrect. We can do a lot theoretically, but I would feel far more comfortable, for example, if in the Japanese experiments that I saw in static testing, the results had been similar to what I have seen in broken buildings throughout the world.

Senator GORTON. Also in your written testimony, you go into the very subject that we have gone into here. Would you say that FEMA can become a stronger leader simply from its own internal efforts, or does it need a change in the authorizing statute or some other prod which comes from the Congress?

Mr. STEINBRUGGE. I cannot answer that except indirectly. I was the first chairman of California's Seismic Safety Commission, and at that time I had learned that the perception of power is often power itself. We had very little authority to do anything, but assuming that we did, and nobody challenged us, we in fact had it, and the Commission now operates very visibly with very little power, if any.

I think having a first-class group of people who are competent, respected in their disciplines, who are fair and have a broad view is a major prerequisite for the lead agency. In this respect FEMA is the logical lead agency among those that are vitally interested in the program.

Further, it is my belief that the program is supported at the very top; having access to the very top, we do not need a dictatorial type of operation. Indeed, we will get farther when we are talking about research and breakthroughs, having people who are highly respected, and FEMA had better listen to what they say, because they tend to be right.

[The statement follows:]

STATEMENT OF KARL V. STEINBRUGGE, CHAIRPERSON, EARTHQUAKE REVIEW PANEL

Mr. Chairman, I am pleased to appear before this Committee and discuss the National Earthquake Hazards Reduction Program (NEHRP) as Chairperson of its Review Panel.

An independent review panel was established by the Federal Emergency Management Agency (FEMA) in September of 1982 to review and report on the Five-Year Program Plan (FY83-FY87) of the National Earthquake Hazards Reduction Program (NEHRP). Specifically, the Panel's mission is to conduct ". . . an assessment of its [the Plan's] adequacy in respect to such topics as general directions, comprehensiveness, gaps or overlaps, and responsiveness to the objectives of NEHRP, as established by law." At a meeting of the Interagency Coordination Committee of the National Earthquake Hazards Reduction Program, the Review Panel chairperson (Steinbrugge) was provided with some general guidance for organizing the Review Panel in order to ensure a balanced group. In addition, he was furnished names of possible candidates for the Review Panel. The Chairperson and the Review Panel have enjoyed complete freedom in all other respects, including final membership, convening, modus operandi, and evaluation of the Program Plan.

The Panelists, all of whom are volunteers, have taken their task seriously. The first meeting of the Panel, held on October 26-27, 1982, found the general thrust of the FEMA draft report to be appropriate, but major sections were unacceptable as to content, emphasis, or style. As a result, the Panelists rewrote and reorganized much of the material. Additionally, the Panel's Executive Committee has met twice to reconcile differences, identify major issues, and otherwise facilitate the preparation of the Panel's final report. On March 1-2, 1983, the Panel concluded its deliberations; its major findings and recommendations are presented in this testimony.

The Panelists are aware of the current budgetary problems and future outlook. They generally transferred monies among tasks or subtasks, keeping the overall original totals unchanged whenever program balance or cost-effectiveness could be improved. However, some comparatively major changes have have been made, and the more important of these are specifically mentioned in the section "Major Issues".

ORGANIZATION OF THE PLAN

In the Program Plan, the activities of the agencies that are part of the National Earthquake Hazards Reduction Program have been grouped under one of the five following headings:

1. Hazard Delineation and Assessment.
2. Earthquake Prediction Research.
3. Engineering Research and Seismic Design.
4. Preparedness Planning and Hazard Awareness.
5. Fundamental Studies.

These Program Elements were derived from the sustantive categories in the original legislation (P.L. 95-124); they are not organized around agency responsibilities per se. Thus, a total National Plan is presented rather than a collection of the agency plan.

STATUS AND ACCOMPLISHMENTS—AN OVERVIEW

Program element 1: Hazard delineation and assessment

Efforts under the first program element have succeeded in identifying major earthquake producing faults in Alaska, Utah, Washington, California, and Nevada and identifying expected magnitudes and recurrence intervals on many of these faults. In the eastern United States, probable earthquake sources have been discovered at depth in the Memphis-St. Louis region, geand studies are continuing near Charleston and along the Ramapo fault zone in New York. From such data and from earthquake patterns over time, researchers prepared national and regional risk maps, showing expected levels of ground motion for time intervals of 10, 50, and 250 years. The national hazard maps completed in 1982 will permit realistic assessments of geologic hazards and ground shaking, contribute to improved structural design criteria, and help provide a better basis for building codes.

Other significant advance within the past few years include: analyses of accelerograms from the severely damaged Imperial County Services Building in El Centro, California; analysis of ground motion records acquired during the magnitude 6.6 Imperial Valley earthquake in October 1979; and field investigations in Alaska, California, Utah, the Memphis-St. Louis region, and Charleston showed that many different geologic units control the potential intensity and extent of earthquake damage. Detailed studies (completed or released in 1981) of U.S. and foreign earthquakes during 1979 and 1980 also were done. They demonstrated that ground motion at any site varies in a very complex way with subsurface structure, with the orientation of the fault, and the manner in which failure propagates along the fault surface.

Program element 2: Earthquake prediction research

Earthquake prediction remains one of the most challenging problems facing the physical sciences today. While posing intriguing and fundamental scientific problems, successful earthquake prediction can reduce human suffering and social disruption by providing a more solid foundation for preparedness action than is now possible. The importance of this research has been recognized in many countries and substantial research programs have been underway for the past decade in China, Japan, and the Soviet Union. Some notable successes have been achieved.

However, reliable short-term predictions (within weeks or days) of damaging earthquakes have proved to be mre difficult than anticipated in 1978, when the United States program began. Seismic research relevant to earthquake prediction has led to a better understanding of the ground motions in the epicentral regions. This information is very useful to engineers in their understanding of the seismic forces used in the design of earthquake resistive buildings. Much basic earth science data have also been collected which helps our understanding of earthquake processes, regional seismicity, and future potential.

Program element 3: Seismic design and engineering research

Significant advances in our understanding of the earthquake response behavior of man-made structures has been made over the last seven years. This increased understanding is being implemented to reduce the earthquake hazard to life and property. Specific examples of some of these acomplishments may be found in tall buildings, dams, nuclear power plants, liquefied natural gas facilities, electrical power generation and distribution systems, off-shore drilling platforms, pipelines, and bridges. Some of the major advances may be summarized as follows:

There is now a good general understanding about the behavior of buildings and other facilities during earthquakes, and of what is required to make them earthquake resistant.

In some states and cities, building codes have been adopted which provide considerable safety for new construction, and in a few cities initial attempts have been made to upgrade existing hazardous construction. A similar situation exists with regard to federally owned or operated buildings.

Some steps have been initiated which will lead to the development and adoption of improved practices in land-use planning and for design and operation of lifeline facilities (e.g. public utilities).

Today's knowledge is far from complete and current engineering practice must continue to evolve as more is learned, such as:

Most major earthquakes in the foreseeable futue, both here and abroad, will provide important lessons. A strong capability must be maintained to permit an understanding and interpretation of such data and to develop new knowledge.

Substantial study should be directed to the problem of existing hazardous buildings and facilities.

A spectrum of goals for the engineering and architectural components of the NEHRP include, among others:

Continued development of manuals for improved seismic design and construction practices.

Continued development of improved model codes and regulations, and assistance to states and cities in their adoption.

Continued steps within the Federal Government to apply good practices to its own buildings and facilities.

Program element 4: Preparedness planning and hazard awareness

The accomplishments and programs of FEMA and related organizations show that progress has been made. Earthquake vulnerability studies which are necessary preludes to response planning and other preparedness efforts have been completed for metropolitan San Francisco, the Los Angeles basin, the Puget Sound area of the State of Washington, metropolitan Salt Lake City, Anchorage, and Honolulu. Others are in progress.

The Southern California Earthquake Preparedness Project (SCEPP) has been a model program for bringing the public and private sectors together to meet local needs, and there is increased interest in multihazard planning rather than planning for response to single types of disasters. The common language being developed to describe earthquake predictions is bringing scientists and decision-makers closer together.

The Panel believes that earthquake hazard mitigation requires greater attention than given to it in the past. To accomplish this, effective risk assessment is necessary with the appropriate maps and studies including the secondary effects of earthquakes involving long-range social and economic impacts.

Program element 5: Fundamental studies

This program element covers basic research aimed at understanding the processes at work that eventually bring about earthquakes. The primary goal is to establish the fundamental knowledge necessary for the potential prediction of earthquakes, destructive ground motions, and how the construction of buildings and other facilities become acceptably earthquake resistant.

The past five years have seen dramatic progress in the development and global implementation of seismic instrumentation with digital recording capabilities. These improvements in seismic data and advances in computer technology have permitted the development of new methods for data processing and analysis. This has resulted in an unprecedented opportunity to provide more advanced, timely, and reliable data and information to the public and scientific communities in a routine fashion.

Some specific examples of important developments in fundamental studies are:

Delineation of "seismic gaps" and a map of seismic potential for the simple major plate boundaries of the world.

Better knowledge and understanding of the state and magnitude of stress in the Earth's lithosphere.

The association of the location of particular intraplate earthquakes with faults and other tectonic features.

A better understanding of the processes that go on in rocks prior to an earthquake, and of the details of the final rupture and energy release.

A better understanding of the dynamic processes of faulting—how a fault rupture begins, spreads, and finally stops, and the evidence seen in seismograms from each of these three stages in the faulting process.

The use of digital recording at selected stations of the Global Seismograph Network and the distribution of these data on magnetic tape in a network-day tape format.

FINANCING OF NEHRP

Two levels of funding are given in the Program Plan as revised by the Panel:

1. Level A generally represents the minimum amount required to sustain the currently projected activities; in some instances the amount represents a lower level of activity.
2. Level B includes Level A funding plus amounts needed to maintain these activities and achieve new or expanded objectives that are considered essential.

Level B funding is strongly recommended by the Panel. Level A figures were derived from many agency sources. In the interests of reasonableness in the current economic climate, Level A was the original target. It was finally concluded that Level A is inadequate in some important instances, and Level B is minimum to achieve the essential objectives of the Act. Summary information presenting the financing for the NEHRP are contained in the accompanying tables.

FIVE YEAR OBJECTIVES AND TASKS TO ACHIEVE THEM

Appendix 1 is a complete listing of the 5 Program Elements and which are divided into Functions and Objectives. Appendix 2 lists the specific tasks necessary to accomplish these Objectives. From these two appendices it becomes possible to identify the major directions of effort during the next 5 years in the NEHRP, including the specific uses for research, studies, and other supporting endeavors (e.g. instrumentation, data collection, and data analyses).

MAJOR ISSUES

Many important issues were discovered and discussed by the Panel. Advice, clarification, and supporting information on procedural matters, the budget process, and other subjects were sought from the various agencies. Their responses were helpful, and often eliminated the problems or reduced them to manageable levels.

There are several major issues, some involving budget increases, which should be brought to the Committee's attention. The Panel's position on these issues are:

1. *Postdisaster mitigation studies.*—Major progress in earthquake hazard reduction has been made as a result of field investigations of earthquake disasters in the U.S. and abroad. The studies of actual events from geophysical, engineering, and socioeconomic viewpoints have directly affected professional practice, education, law, public policy, research, and other critical components of disaster mitigation. However, funding has been insufficient to do little more than reconnaissance visits, and great deal more can be learned applicable to the U.S. through more extensive investigations.

The Panel recommends that an initial appropriation of $500,000 be made on a "no-year" basis to support comprehensive initial field investigations which are to be coordinated by FEMA as the lead agency. The purposes of such investigations are: (1) to collect critical perishable data, (2) identify subjects and costs for longer term investigation, and (3) interpret and disseminate the results for application.

2. *FEMA's leadership role in earthquake.*—There was some dissatisfaction among the majority of the Panelists regarding FEMA's past leadership role in the National Earthquake Hazards Reduction Program. The high hopes in the scientific and engineering communities resulting from the 1978 report of the Working Group on Earthquake Hazard Reduction in the Office of Science and Technology Policy have not been adequately realized.

Currently there are strong indications that FEMA will play a stronger leadership role, but the details remain to be worked out.

The Panel recommends that FEMA appoint a strong independent advisory group on a parmanent basis. In advising FEMA, this group would work with similar groups within USGS, NSF, NBS, and others as needed to strengthen the coordination required as one part of FEMA's lead agency role. Supporting staff within FEMA should be highly qualified in the affected disciplines and committed full time to the Program.

3. *National experimental facility(ies).*—The Program Plan now before the Panel includes a new program for a National Experimental Facility or Facilities. The cost for this program is estimated now to be about $350 million. This is a very large amount when taken in the context of the current earthquake budgets.

The Panel believes that much more study should be given to this issue before a decision is made. For an example of questions to be looked at, what is the cost-effectiveness of this proposal in the context of the entire earthquake engineering program? The answer requires a broad perspective.

The Panel recommends that FEMA, in its lead role, ask the President's Science Advisor to impanel an appropriate group to decide this issue.

4. *Modernizing existing research facilities.*—Earthquake engineering related equipment has become obsolete in universities and elsewhere, and woefully so in many cases. The Panel believes that modernization is mandatory based on a recent preliminary survey.

5. *Proposed elimination of National Bureau of Standards program in building research.*—The Review Panel has recently been advised of the propsal to eliminate the entire National Bureau of Standards program in building research; the Panel did not have sufficient time to adequately examine all facets of this proposal.

Earthquake engineering is a component part of building research and, a such, the National Bureau of Standards was assigned a significant role in the National Earthquake Hazards Reduction Act.

In the real world of building design and construction in seismic areas, earthquake engineering is intertwined with almost all other aspects of building construction. For examples, life safety during and after earthquakes involve the integrity of stairs, ceilings, and post-earthquake fire fighting capabilities in addition to the integrity of beams and columns. Integrated building technology such as that conducted by the National Bureau of Standards is required in order to fully implement the specialized research conducted by academia and others. This integrated technology may take many forms, from testing to building code improvements. While many such activities can be accomplished by universities and by trade organizations, a national viewpiont which is broadly based and without regional or product bias is vital to insure a balanced program.

In connection with the NEHRP, the technical support that NBS provides to FEMA is essential. If this support were to disappear, it is mandatory that FEMA obtain it elsewhere.

6. *Concluding remarks.*—In closing, Mr. Chairman, allow me to state that progress has been made in the NEHRP, but much still remains to be accomplished to achieve the objectives that were set by the Congress in passing Public Law 95-124. Accordingly, the Panel recommends to this Committee that this law be reauthorized for at least 2 years to allow the Program to proceed in an orderly and cost-effective manner.

Thank you, Mr. Chairman. If you have any questions, I will be pleased to try to answer them.

TABLE 1.—BUDGET SUMMARY, NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM PLAN, FISCAL YEAR 1983–87

[In thousands of dollars]

Program elements	Fiscal year 1983 (actual)	Projected in constant fiscal year 1983 dollars							
		fiscal year 1984		fiscal year 1985		fiscal year 1986		fiscal year 1987	
		A	B	A	B	A	B	A	B
I. Hazard delineation and assessment	16,210	15,210	22,020	16,086	21,916	16,466	23,600	16,466	23,600
II. Earthquake prediction research	14,460	10,390	16,400	10,800	17,700	10,800	21,400	10,800	25,100
III. Seismic design and engineering research	16,200	22,665	34,400	24,500	37,400	23,925	36,000	21,525	33,500
IV. Preparedness planning and hazard awareness	4,670	4,850	7,400	5,150	7,150	4,900	6,550	4,125	6,250
V. Fundamental studies	11,650	12,550	19,900	13,350	21,600	14,250	24,000	15,250	21,800
NEHRP total	63,190	65,665	100,120	69,886	105,766	70,341	111,550	68,166	110,250

[APPENDIX 1]

PROGRAM ELEMENTS AND OBJECTIVES OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM PLAN, FISCAL YEAR 1983 TO FISCAL YEAR 1987

I. HAZARDS DELINEATION AND ASSESSMENT

1. *Determination of current tectonics and earthquake potential.*—To maintain and expand ongoing efforts to delineate the tectonic framework and earthquake potential of various seismogenic zones in the U.S. through geophysical and geological field observations and data analysis.

2. *Earthquake hazards assessments (national and regional).*—To expand efforts to delineate, evaluate, and document earthquake hazards and risks in urban areas and earthquake-prone regions of the U.S.

3. *Strong ground-motion recording and analysis (engineering seismology).*—To acquire and disseminate data on strong ground motions, which contribute to the development of earthquake-resistant design/construction and earthquake-resistant design/construction and earthquake prediction capability, and maintain a strong national ground-motion observational network.

4. Postdisaster mitigation studies.—To create a postdisaster mitigation studies program, coordinated by FEMA, to collect critical perishable data, identify subjects and costs for longer-term investigation, and interpret and disseminate the results for application in the public and private sectors.

NRC's program of nuclear-related earth sciences.—To provide an improved data base for licensing decisions and for development of standards applicable to the safety of nuclear facility sites.

II. EARTHQUAKE PREDICTION RESEARCH

1. *Precursor evaluation and prediction methodology.*—To obtain data on precursory phenomena and establish the statistical properties of these phenomena for application in prediction methodologies.

2. *Earthquake prediction pilot field studies.*—To conduct earthquake prediction pilot experiments in heavily populated regions of the U.S. at greatest risk from a damaging earthquake.

3. *Theoretical, laboratory and fault zone studies.*—To conduct theoretical, laboratory, and fault zone studies.

4. *Induced seismicity.*—To get a better understanding of the processes which may induce earthquakes (particularly reservoir-induced seismicity), so that techniques may be devised to predict the tectonic response of sites where major construction projects are planned.

III. SEISMIC DESIGN AND ENGINEERING RESEARCH

1. *Development of model codes and manuals of practice.*—To develop and publish seismic safety standards, codes and manuals and lifelines, and promote their application by engineering/design professionals and public officials.

2. *Fundamental and applied engineering research.*—To continue and expand fundamental and applied research aimed at improving the resistance of existing and new structures to earthquake damage.

3. *Modernization of existing laboratory equipment and facilities.*—To modernize existing experimental and analytical earthquake laboratory equipment, instrumentation and research facilities.

4. *National earthquake experimental capability.*—To evaluate the costs and benefits of constructing a major U.S. experimental capability that will allow engineering researchers to make full-scale performance tests of the seismic safety of buildings and other structures.

IV. PREPAREDNESS PLANNING AND HAZARD AWARENESS

1. *Development of earthquake hazard mitigation strategies.*—To take a lead role in developing strategies to reduce the loss of life, destruction of property, economic instability, and the adverse impact on our national defense capability that would result from a catastrophic earthquake.

2. *Federal response planning.*—To develop and test Federal response plans and preparedness measures to cope with the damage and casualties of a catastrophic earthquake.

3. *State and local preparedness planning.*—To coordinate and provide support for comprehensive State and local preparedness and mitigation planning in twelve heavily-populated, earthquake-prone areas of the U.S.

4. *Multihazard preparedness planning.*—To develop and implement prototype multihazard mitigation and preparedness plans in selected earthquake-prone areas of the U.S.

5. *Public education.*—To enhance the understanding of policymakers, decisionmakers, and the general public in earthquake-prone communities about the level of risk, hazards to life and property, and measures they can take to reduce personal and community vulnerability.

6. *Societal response research.*—To continue and expand research on the social, economic, legal, and political factors associated with the adoption and use of technological and social adjustments to earthquake hazards.

V. FUNDAMENTAL STUDIES

1. *Implications of plate tectonics.*—To continue and expand ongoing observational, laboratory, and theoretical studies of plate motions and interactions in order to gain a greater understanding of the earthquake process.

2. *Earthquake process.*—To improve our understanding of the physical processes in nature that lead to or constitute an earthquake.

3. *Earthquake data and information services.*—To maintain and expand global and national networks of seismograph stations, which provide a sound and dependable data base for fundamental studies in observational seismology. Support basic and applied research to ensure that data collection and analysis techniques keep pace with technological advances in instrumentation and new developments in theoretical advances in instrumentation and new developments in theoretical seismology.

NASA's geodynamics program.[1]—To model crustal strain changes in the western U.S. and Alaska and similar tectonic boundaries in order to understand how crustal deformation is related to earthquake occurrences;

To produce (over a period of ten to twenty years) models of the present movement and deformation of major tectonic plates in order to understand the forces driving the plates;

To identify the causes of changes in polar motion and earth rotation; and

To formulate an integrated comprehensive global model of dynamics processes.

[APPENDIX 2]

OBJECTIVES AND SPECIFIC TASKS FOR PROGRAM ELEMENT I: HAZARDS DELINEATION AND ASSESSMENT, FISCAL YEAR 1983 TO FISCAL YEAR 1987

1. DETERMINATION OF CURRENT TECTONICS AND EARTHQUAKE POTENTIAL

Objection: To maintain and expand ongoing efforts to delineate the tectonic framework and earthquake potential of various seismogenic zones in the U.S. through geophysical and geological field observations and data analyses.

Task 1: Delineate seismically active faults and the structure of seismic zones by monitoring regional earthquake activity in California, Alaska, Puget Sound, western Nevada, the eastern Sierras, central Utah, upper Mississippi embayment, and southern and northeastern U.S.

Task 2: Identify and map active crustal faults and use geophysical and geological data to determine the geometry and structure of seismogenic zones in eastern and western States.

Task 3: Use geological and geophysical data to estimate strain accumulation, fault slip rates, maximum earthquakes, and recurrence intervals for faults or seismogenic zones identified and delineated in Tasks 1 and 2 above.

2. EARTHQUAKE HAZARDS ASSESSMENTS (NATIONAL AND REGIONAL)

Objective: To expand efforts to delineate, evaluate, and document earthquake hazards and risks in urban areas and earthquake-prone regions of the U.S.

Task 1: Establish an accurate, reliable national earthquake data base.

Task 2: Delineate and evaluate earthquake hazards in the U.S. on a national scale.

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[1] Research activities indirectly related to the NEHRP.

Task 3: Delineate and evaluate earthquake hazards in the earthquake-prone urban areas in the West (areas in and around Los Angeles-San Diego, Salt Lake City, Seattle and Anchorage).

Task 4: Delineate and evaluate earthquake hazards and risk in earthquake-prone regions in the East (areas in the mid-Mississippi Valley; San Juan, Puerto Rico; Charleston, South Carolina; and Boston).

Task 5: Expand regional ground-shaking and ground failure studies in the regions identified in Tasks 3 and 4 above.

3. STRONG GROUND-MOTION RECORDING AND ANALYSIS (ENGINEERING SEISMOLOGY)

Objective: To acquire and disseminate data on strong ground motions, which contribute to the development of earthquake-resistant design/construction and earthquake prediction capability, and maintain a strong national ground-motion observational network.

Task 1: Operate a national network of strong-motion instruments and deploy special temporary arrays of instruments for acquiring aftershock and structural response data.

Task 2: Develop the theoretical basis for the prediction of the nature of strong ground-motion and analysis techniques for the most useful application of strong ground-motion data for engineering design.

4. POST-DISASTER MITIGATION STUDIES

Objectives: To create a post-disaster mitigation studies program, coordinated by FEMA, to collect critical perishable data, identify subjects and costs for longer-term investigation, and interpret and disseminate the results for application in the public and private sectors.

NRC'S PROGRAM OF NUCLEAR-RELATED EARTH SCIENCES[1]

Objective. To provide an improved data base for licensing decisions and for development of standards applicable to the safety of nuclear facility sites.

Task 1: Continue support for the operation of seismographic networks in regions of historic seismicity, particularly in the area east of the Rocky Mountains. Continue support of analysis of network data including epicenter bulletin preparation, improved magnitude determinations, source parameter determinations, and propagation path characteristics.

Task 2: Using seismological, geophysical and geological techniques, identify the causative geological structures for seismicity in the eastern U.S. Delineate the shape and extent of these causative structures.

Task 3: Study the propagation path characteristics for the eastern U.S. over a frequency band of interest to nuclear facilities. Compare these with those of the western U.S.

Task 4: Support the acquisition and analysis of strong ground-motion data.

OBJECTIVES AND SPECIFIC TASKS FOR PROGRAM ELEMENT II: EARTHQUAKE PREDICTION RESEARCH, FISCAL YEAR 1983 TO FISCAL YEAR 1987

1. PRECURSOR EVALUATION AND PREDICTION METHODOLOGY

Objective: To obtain data on precursory phenomena and establish the statistical properties of these phenomena for application in prediction methodologies.

Task 1: Obtain data on significant changes in the physical properties of the Earth's crust prior to the occurrence of earthquakes.

Task 2: Analyze and evaluate the statistical properties of various phenomena and develop prediction methodologies that will lead, in a systematic manner, from long-range to short-term earthquake predictions.

2. EARTHQUAKE PREDICTION PILOT FIELD STUDIES

Objective: To conduct earthquake prediction pilot experiments in heavily populated regions of the U.S. at greatest risk from a damaging earthquake.

Task 1: Conduct a comprehensive earthquake prediction experiment in the San Andreas fault zone of southern California.

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[1] Research activities indirectly related to the NEHRP.

Task 2: Conduct a comprehensive earthquake prediction experiment in the San Andreas fault zone of central California.

Task 3: As funds allow, conduct similar experiments in other seismically active regions of the U.S.

3. THEORETICAL, LABORATORY, AND FAULT ZONE STUDIES

Objective: To conduct theoretical, laboratory, and fault zone studies.

Task 1: Conduct theoretical analyses focused on the nature of earthquake instability in realistic fault models, time-predictable and slip-predictable models of the earthquake cycle, and crustal response at plate boundaries in various geometrical configurations and under varying driving conditions.

Task 2: Conduct laboratory investigations of faulting and fault zone materials.

Task 3: Measure the physical conditions (stress, temperature, and pore pressure) and material properties of fault zones.

4. INDUCED SEISMICITY

Objective: To get a better understanding of the processes which may induce earthquakes (particularly reservoir-induced seismicity), so that techniques may be devised to predict the tectonic response of sites where major construction projects are planned.

Task 1: Conduct geological and geophysical field investigations in regions where earthquakes have apparently been induced by fluid injection or withdrawal.

Task 2: Conduct theoretical studies and case histories of reservoir-induced seismicity.

OBJECTIVES AND SPECIFIC TASKS FOR PROGRAM ELEMENT III: SEISMIC DESIGN AND ENGINEERING RESEARCH, FISCAL YEAR 1983 TO FISCAL YEAR 1987

1. DEVELOPMENT OF MODEL CODES AND MANUALS OF PRACTICE

Objective: To develop and publish seismic safety standards, codes, and manuals of practice for the construction or reconstruction of buildings and lifelines, and promote their application by engineering/design professionals and public officials.

Task 1: Complete the comprehensive seismic design criteria developed by professional organizations for commercial and industrial structures and lifelines, and promote their application in the public and private sectors.

Task 2: Update and improve these design criteria, as ongoing research on seismic safety suggests.

Task 3: Complete and promulgate design codes and standards for use in all Federal buildings.

Task 4: Develop and publish guidelines for measuring and evaluating the seismic resistance of existing buildings.

Task 5: Develop and publish seismic safety guidelines for mitigating site hazards.

Task 6: Develop and publish a manual of practice for assessing the effects of local soil conditions on structures during earthquakes.

Task 7: Develop and publish model codes for upgrading existing buildings to make them earthquake-resistant.

Task 8: Develop and publish manuals of practice to help engineers to assess and abate the vulnerability of lifeline facilities to earthquake damage.

2. FUNDAMENTAL AND APPLIED ENGINEERING RESEARCH

Objective: To continue and expand fundamental and applied research aimed at improving the resistance of existing and new structures to earthquake damage.

Task 1: Continue and expand model tests and field investigations to study and evaluate the relationships between soil conditions and structures when subjected to strong ground motions.

Task 2: Continue and expand ongoing research on the loads on structures and lifelines produced by earthquakes and tsunamis, to be used in developing engineering guidelines for mitigating earthquake damage.

Task 3: Continue and expand research on the nature and effects of destructive ground motions on structures of all types.

Task 4: Continue and expand field investigations and laboratory analyses that will allow engineers to predict the strength and dynamic behavior of various types of structural systems and their components.

Task 5: Continue and expand architectural research and disseminate the findings to the professional community.

3. MODERNIZATION OF EXISTING LABORATORY EQUIPMENT, INSTRUMENTATION, AND FACILITIES

Objective: To modernize aging experimental and analytical earthquake laboratory equipment, instrumentation, and facilities.

4. NATONAL EARTHQUAKE EXPERIMENTAL CAPABILITY

Objective: To evaluate the costs and benefits of constructing a major U.S. experimental capability that will allow engineering researchers to make full-scale performance tests of the seismic safety of buildings and other structures.

OBJECTIVES AND SPECIFIC TASKS FOR PROGRAM ELEMENT IV: PREPAREDNESS PLANNING AND HAZARD AWARENESS, FISCAL YEAR 1983 TO FISCAL YEAR 1987

1. DEVELOPMENT OF EARTHQUAKE HAZARD MITIGATION STRATEGIES

Objective: To take a lead role in developing strategies to reduce the loss of life, destruction of property, economic instability, and the adverse impact on our national defense capability that would result from a catastrophic earthquake.

Task 1: Adopt and publish standards for Federal buildings equivalent to or in excess of local standards.

Task 2: Recognize and allow earthquake damage mitigation costs in Federal construction grants to local governments.

Task 3: Study the organization of local disaster response in earthquake-prone areas, and recognize the role of all jurisdictions, including special districts and regional organizations. Adapt to the local organization or take a lead role in changing it. Where necessary, identify and initiate changes to impove (a) the response by all levels of government during a major disaster and (b) the impact of Federal policies and practices on local land use planning and construction before and after a disaster.

Task 4: Take a leadership role in revamping banking and insurance industry policies and standards in earthquake-prone areas. These institutions, which are beyond the sphere of local influence, have a major impact on building, reconstruction, and safety practices in high-risk areas.

Task 5: Predetermine the level of disaster assistance the Federal Government will make available to public and private agencies in the event of a major disaster. Inform local agencies accordingly so they may make plans to supplement their Federal allocation and develop realistic response and recovery plans.

2. FEDERAL RESPONSE PLANNING

Objective: To develop and test Federal response plans and preparedness measures to cope with the damage and casualties of catastrophic earthquake.

Task 1: Develop Federal planning guidance; prepare Agency response plans, and initiate development of a Headquarters feasibility exercise.

Task 2: Conduct Headquarters feasibility exercise, finalize Agency response plans, inititate development of full-scale field exercise of response to a catastrophic earthquake in California, and conduct a full-scale exercise.

Task 3 through Task 5: Based on the results of the California test, conduct full-scale exercise in the following nine earthquake-prone areas; Anchorage, Seattle, Salt Lake City, Central U.S., Hawaii, Boston, Charleston (SC), New York, and Puerto Rico.

3. STATE AND LOCAL PREPAREDNESS PLANNING

Objective: To coordinate and provide support for comprehensive preparedness and mitigation planning in twelve high-risk, heavily populated areas.

Task 1: Expand work on the SCEPP prototype plan, which covers the five high-risk counties of the Los Angeles metropolitan area.

Task 2 through Task 12: Develop and complete plans for the following high-risk areas: San Francisco Bay area (nine counties), San Diego (city and county), Central U.S. (approximately 150 local jurisdictions in seven States), Hawaii, Puget Sound, Alaska, Salt Lake, City, Charleston (SC), Boston, Upper New York State, and Puerto Rico.

4. MULTI-HAZARD PREPARDENESS PLANNING

Objective: To develop and implement prototype multi-hazard mitigation and preparedness plans for selected earthquake-prone areas.

5. PUBLIC EDUCATION

Objective: To enhance the understanding of policymakers, decisionmakers, and the general public in earthquake-prone areas about the level of risk, hazards to life and property, and measures they can take to reduce personal and community vulnerability.

Task 1: Develop and disseminate educational materials on the cause and effects of earthquakes, earthquake prediction, earthquake preparedness, life safety, and hazard mitigation measures.

Task 2: Facilitate community outreach programs which support the use and dissemination of earthquake information.

6. SOCIETAL RESPONSE RESEARCH

Objective: To continue and expand research on the social, economic, legal, and political factors associated with the adoption and use of technological and social adjustments to earthquake hazards.

Task 1: Develop knowledge about the socioeconomic aspects of hazards mitigation.

Task 2: Increase the base of knowledge about preparedness for earthquakes.

Task 3: Provide a basis for improving the dissemination and awareness of information on hazards and its utilization by public and private decisionmakers and the public.

Task 4: Increase the base of knowledge on the impact of private sector institutions (e.g., banking and insurance groups) on hazard mitigation and their appropriate roles in society.

OBJECTIVES AND SPECIFIC TASKS FOR PROGRAM ELEMENT V: FUNDAMENTAL STUDIES, FISCAL YEAR 1983 TO FISCAL YEAR 1987

1. IMPLICATIONS OF PLATE TECTONICS

Objective: To continue and expand ongoing observational, laboratory and theoretical studies of plate motions and interactions in order to gain a greater understanding of the earthquake process.

Task 1: Initiate new studies and expand current efforts to investigate the deep continental lithosphere.

Task 2: Develop reliable ocean-bottom seismometers (OBS) for long-term recording of seismicity (particularly along ridge crests, fracture zones, and near subduction zones) and for long-range reflection-refraction profiling.

Task 3: Conduct studies of the relationship of earthquakes to plate tectonics and geology.

Task 4: Continue and expand U.S. participation in international seismological research and hazards mitigation projects.

2. EARTHQUAKE PROCESS

Objective: To improve our understanding of the physical processes in nature that lead to or constitute an earthquake.

Task 1: Augment existing studies of dynamic source mechanics (seismic-source phenomena) with very long-range characteristics.

Task 2: Develop more efficient, sophisticated techniques for computing synthetic seismograms, which have contributed great insight into seismic sources.

Task 3: Initiate laboratory studies on the time-dependent mechanical properties of rock to complement theoretical and field studies of faults and fault-zone material.

Task 4: Continue work on a model of fracture mechanics to complement laboratory studies of catastrophic failure in rock.

3. EARTHQUAKE DATA AND INFORMATION SERVICES

Objective: To maintain and expand global and national networks of seismograph stations, which provide a sound and dependable data base for fundamental studies in observational seismology. Support basic and applied research to ensure that data collection and analysis techniques keep pace with technological advances in instrumentation and new developments in theoretical seismology.

Task 1: Install, operate, maintain, and improve standardized networks of seismograph stations. Process and provide digital seismic data on magnetic tape in network-day tape format.

Task 2: Collect, analyze, and disseminate seismological information to the public, the research community, and those involved in earthquake prediction and hazards assessment.

Objectives and Specific Tasks for Program Element V: Fundamental Studies, Fiscal Year 1983 to Fiscal Year 1987

NASA'S GEODYNAMICS PROGRAM [1]

Objectives: To model crustal strain changes in the western U.S. and Alaska and similar tectonic boundaries in order to understand how crustal deformation is related to earthquake occurrence;

To produce (over a period of ten to twenty years) models of the present movement and deformation of major tectonic plates in order to understand the forces driving the plates;

To identify the causes of changes in polar motion and earth rotation;

To formulate an integrated, comprehensive global model of dynamics processes.

Task 1: Continue and expand studies of regional crustal deformation in California and other sites in the West, and initiate new crustal measurement programs in Alaska, Mexico, and South America in cooperation with other nations.

Task 2: Continue and expand the Crustal Dynamics Project, which uses U.S.-owned which uses fixed laser and microwave facilities deployed within and outside the U.S. to measure the rate and direction of motion on the world's major tectonic plates (North American, Pacific, Australian, South American and Eurasian).

Task 3: Continue and expand studies of the interval deformation of the North American, Pacific, and Australian plates.

Task 4: Continue and expand NASA's worldwide network of laser stations and the new network of microwave observation stations established by NOAA with NASA's assistance, both aimed at obtaining more accurate, short-term data on earth rotational dynamics.

Task 5: Continue and improve NASA-sponsored studies of the lithosphere using data acquired from satellites, including modelling of the earth's gravity field. The studies will improve our understanding of the structure and deformation of the solid earth and also fluid convection in the mantle.

Senator GORTON. I thank you very much. We appreciate your coming here. We hope that your home is still there when you get back to southern California.

That concludes the portion of this morning's hearing dedicated to the Earthquake Hazards Reduction Act. The subcommittee will now recess, and reconvene at 10:30 a.m. to hear testimony on the National Science Foundation.

[Whereupon, at 10:07 a.m., the committee was adjourned, to reconvene at 10:30 a.m., of the same day.]

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[1] Research activities indirectly related to the NEHRP.